Agriculture
Canada

RESEARCH BRANCH REPORT

1986

RAPPORT DE LA DIRECTION GÉNÉRALE DE LA RECHERCHE

Program Coordination Directorate
Ottawa, Ontario

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RESEARCH RECHERCHES

Canada

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Ottawa, Ontario

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[1] Appointed 1 March 1986.

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INTRODUCTION

Over the year, the Program Coordination Directorate (PCD) has fulfilled its role as described in the Preface and has also addressed a number of new demands arising from government policy. The 1986 Budget Speech outlined overall fiscal cutbacks, which resulted in the development of a program rationalization strategy for the branch. Nonmission-dedicated resources were carefully examined with a view to identifying areas for further resource reductions. As a result, a decision to centralize branch senior management and associated administration activities was taken, which should result both in an enhanced environment for decision making and in resource savings for the branch.

PCD responded to the recommendations outlined in the Auditor General's report of 1986, which contained a major section on the management of research operations. A human resource management strategy was drafted and guidelines and criteria for project selection and assessment were developed.

New directions for the branch started to emerge toward the end of the year, as increased emphasis began to be placed on industry relations, federal–provincial memoranda of understanding, CASCC–CARC restructuring, and university–industry–provincial partnerships.

W. Baier
Acting Director General

POLICY, PLANNING, AND CONTROL

Response to government initiatives

The Program Coordination Directorate (PCD) addressed the challenge of advising branch management on mechanisms to implement government priorities aimed at resource reduction in a manner that would have the least effect on program delivery. The concern was to ensure a viable research organization to meet the needs of the agri-food industry in a climate of downsizing of resources.

Program rationalization strategy. In response to the fiscal cutbacks outlined in the 1986 Budget Speech, the directorate prepared a program rationalization strategy to accommodate person-year reductions that would assist the department to meet its overall objectives. The strategy identified three program categories: programs to be strengthened, those to be maintained, and those to be consolidated. At the national level, no programs are expected to be eliminated entirely; a core program will be maintained in at least one establishment. Implementation of the strategy will be reviewed to take full advantage of attrition and initiatives such as voluntary retirement schemes.

Nonmission-oriented operations. In 1986, working groups were established to examine all nonmission-dedicated resources, with the goal of identifying further resource savings. The PCD provided major input and support. The major functional areas of personnel and training, information and publishing, co-location, land divestment, finance, administrative services, operational planning, and systems and consulting were reviewed. As a result of studies on regional departmental organizations, the Research Branch concluded that regional restructuring would be a feasible mechanism for achieving resource savings. It was agreed that restructuring would proceed on the basis of three regions: Eastern, Central, and Western, each headed by a director general. The regions would be supported by an expanded Program Coordination Directorate, to be renamed the Priorities and Strategies Directorate. Full implementation is expected to take place on 1 April 1987.

Branch advisory committees

To assist in identifying priority research needs in relation to the market-oriented, commodity-based development strategies, PCD initiated the establishment of branch advisory committees, with membership from across the Research Branch. Their purpose is to engage the expertise of senior research scientists in support of the activities of research coordinators and branch decisions. These committees would examine branch operations in commodity and non-commodity areas for delivery of effective and efficient operational output. In addition, they would support the branch representatives on the commodity teams. The establishment of branch advisory committees was finalized in October 1986 and several are now active.

Program specialists' meeting

The program specialists' meeting, held 4 November 1986, provided an excellent opportunity for regional representatives to meet with members of the directorate on issues of mutual concern, with emphasis on operational and work planning. The Deputy Minister's objectives and priorities, as well as the priority goals for the commodity strategies, were outlined as the basis for work planning in 1987–1988.

Topics discussed included industry relations and collaborative research, cost recovery, commodity strategies, the program strategy for soil and water, and a profile of activities of professional staff. The new departmental planning process was described, noting that a major improvement would be closer involvement by branch heads in strategic issues. Extensive discussion took place on methods to simplify and streamline the establishment work planning process. The procedure agreed upon would provide for one work plan for each branch project (four-digit code) at an establishment, which would consist of an objective, resources, goals, and performance indicators. The need for a clear, concise definition of project was strongly identified, and will be addressed in future discussions relating to the Decision Information Systems Plan.

Operational plan

In preparation for the 1987 branch head operational plan, the Program Coordination Directorate prepared responses to the Deputy Minister's priorities for the coming year under the headings of shared jurisdiction, high-profile issues, facilitating structural adjustment of the sector, and management issues. The responses from all senior managers in the department provided the basis for the compilation of the department strategic directions document. The Research Branch was assigned the lead role in implementing the strategies outlined in the technology enhancement priority. The directorate was responsible for developing the branch priorities and strategies that would address department priorities as well as responding to the recommendations put forward in the National Agriculture Strategy by the ministers responsible for agri-culture in Canada. The 1987 priorities from the commodity development strategies were also taken into consideration.

The resulting branch head operational plan has set the direction for the branch during 1987–1988 and beyond. A major enhancement in this plan is the extensive cooperation that is required among branches in order to achieve the intended results. The Program Coordination Directorate must play a major consultative role to ensure that the cooperative goals are attained.

Human resource planning

In July 1986 the Assistant Deputy Minister, Research, established a committee to develop a Human Resources Plan for the Research Branch, with special attention to research scientists. This action was taken in response to recommendations in the Neilsen Task Force report and the 1986 Auditor General's report. Leadership was provided by the Program Coordination Directorate.

In order to establish a mechanism to determine the needs of the branch for research scientists, two surveys were conducted to determine (*1*) the capabilities of the research scientists now in the branch (supply), and (*2*) the forecast skills required by the branch in 1991 (demand). The supply inventory was completed by individual research scientists. The demand surveys were sent to directors general but in most instances they were completed by establishment directors.

Considerable attention was given to the management of research scientists. Issues that surfaced during consultation were studied by the committee, various options examined, and recommendations proposed. These recommendations aim at ensuring that the scientists in the branch are motivated, challenged, and sufficiently rewarded. The implementation of the plan in 1987 and beyond should ensure that the branch has the necessary scientific human resources and that it uses them in the most efficient manner to carry out its mission.

Operational reporting and control

Decision Information Systems Plan. The branch-wide project entitled "Decision Information Systems Plan" was developed during the first part of the year by a working group made up of branch personnel, specialists from the Corporate Management Branch, and an outside consultant. The aim of the project was to provide a solid base for more efficient and effective information systems as well as a mechanism for operational control. The project included the development of business and information models and an inventory of current data bases and systems. The Program Coordination Directorate played an active role in this project through membership on the working group. Ten sub-projects were identified for implementation as resources become available, with top priority being given to "Project control in stations" and "Establishment accounting."

Project selection and assessment. In response to the Auditor General's recommendation for improved management of research operations, the PCD developed a document entitled "Guidelines and criteria for project selection and assessment." This document provides standard guidance to assist managers in selecting research studies that will respond to the needs of clients as well as relating directly to establishment, branch, and department priorities and objectives.

Reporting to Treasury Board and Parliament. The Program Coordination Directorate prepared the Research Branch sections in two departmental reports to Treasury Board and Parliament: the *Main Estimate Part III* and the *Annual Report of the Minister.* These reports provide an opportunity for the branch to clearly outline its concerns, opportunities, and resource needs for the upcoming fiscal year, and to describe its achievements of the previous year.

Quarterly reporting. The PCD provided leadership in coordinating the preparation of quarterly reports across the branch. The reports at all management levels are prepared according to the structure defined in the Operational Planning Framework. Revised guidelines for regions resulted in the documentation of concise, relevant information with focus on major variances and achievements, allowing for ready amalgamation of pertinent information into the branch head report.

Directors' work planning meeting

A directors' work planning meeting, organized by the Program Coordination Directorate, was held in Ottawa on 2–4 June 1986. The meeting coincided with the centennial celebrations of agricultural research, and the agenda on 2 June included tours of the Central Experimental Farm and attendance at the official centennial ceremonies. The 2nd and 3rd days focused on presentations and discussions aimed at developing ways to continue to make progress in the face of new challenges during and after 1986. Under the theme of management, a number of pertinent topics were addressed: how to manage with commodity strategies, industry relations, how to manage downsizing, opportunities, and problems in personnel management, and the Auditor General's report. The discussions allowed all participants to voice their concerns and offer suggestions. Other presentations dealt with the topics of data bases and the federal–provincial working groups on technology transfer and soil and water issues.

Cost recovery

PCD continued to consider the various possibilities for cost recovery in Research Branch. Although there is pressure to explore all possible sources of revenue in the short term, the branch, by nature of its mandate and the longer time frame required for effective delivery of R&D programs, is focusing its cost recovery efforts on expenditure reduction rather than on revenue generation. In principle, areas of R&D that generate significant revenues should become prime candidates for privatization.

The predominant part of industry related involvement, both current and future, is in collaborative R&D. The current industry support in kind is not translatable into revenue because industry insists on (*1*) controlled and targeted contributions to specific collaborative R&D projects, and (*2*) supplementing rather than subsidizing current levels of research.

Industry relations

The PCD is placing increased emphasis on its interactions with the agri-food industry. With the assistance of senior branch officials, draft policy and guidelines were developed on collaborative R&D with industry, in order to facilitate co-development and transfer of technology. A paper entitled *Industry participation in research priority setting* documents the tremendous involvement that exists with industry at the grass roots level. It also presents recommendations and possible new approaches to enhance the effectiveness and visibility of input from industry into research priority setting. Seminars at stations are being conducted to inform senior scientists of the scope and possibilities of branch relations with industry and to identify specific technology for potential co-development and transfer.

CROP PRODUCTION

Input to policy, planning, and program development

The directorate represented the branch on the departmental market-oriented, commodity-based development strategy teams, which developed commodity strategies for the Grains and Oilseeds, Horticulture, and Special Crops sectors. These strategies identified actions and recommendations to address priority constraints and opportunities to increase access to markets.

National Advisory Committees on Grains and Oilseeds, Horticulture, and Special Crops were established within the Research Branch to assist in delivering effective and efficient research programs and to provide appropriate regional inputs to program priorities, particularly in relation to departmental commodity strategy developments.

Directorate personnel organized and/or participated in workshops on quackgrass and potato pests as well as a review of the berry crops research program in the Atlantic Region.

Appropriate research goals for the crops research programs were developed and integrated into the branch head's work plan. Significant research accomplishments and deviations from the work plan were documented on a quarterly basis.

Interbranch and interdepartmental activities

The directorate represented the branch on the National Research Council Committee on Industrial Research Assistance (IRA), which evaluates and recommends on proposals for the IRA program funding and on the departmental New Crop Development Fund Advisory Board, which allocates funds to projects having the objective of evaluating the potential of new crops for Canadian production.

The directorate represented the branch on the Steering Committee, which reviewed and recommended changes to the seed potato management program in the Food Production and Inspection Branch.

Extramural activities

Relations with the seed industry were maintained through directorate membership in the Canadian Seed Growers' Association and in the SeCan Association as well as by frequent interactions with the Canadian Seed Trade Association.

Directorate personnel organized and held consultations on research needs and priorities with representatives of the floriculture and nursery industries, and participated with other branches of Agriculture Canada in general discussions of industry needs and government services.

Directorate personnel cooperated with the Canadian Horticultural Council in the publication of a report on horticultural research carried out at all federal and provincial government establishments and at universities in Canada.

The directorate represented the branch on committees respecting asparagus and potato chips research programs supported by funds from industry and remission of duties on products imported into Canada from the United States.

Consultation, advice, and leadership were provided in the crops area at the national level through representation on the Canada Committee on Crop Production Services as well as on the Expert Committees on Horticulture, Weeds, Plant Gene Resources, and Grains and Oilseeds.

ANIMAL PRODUCTION

Input to policy, planning, and program development

An economic analysis of the returns of the animal research program productivity between 1968 and 1985 was prepared under contract for Program Evaluation Division. The study concluded that animal productivity research has generated and likely will continue to generate substantial net benefits to the Canadian economy.

Poultry and sheep programs were reviewed by external committees made up of representatives from universities, industry, and the provincial governments. These established the base for national coordination of the programs.

Interbranch and interdepartmental activities

PCD assisted Commodity Coordination Directorate in the preparation of the commodity plans for the department. Representation was provided on the Canadian Council of Animal Care.

External activities

PCD has played a major role in ensuring continued cooperation and consultation between the Research Branch and the Dairy Farmers of Canada, the Canadian Pork Council, the Canadian Cattlemen's Association, and the Canadian Sheep Council.

NATURAL RESOURCES

Input to policy, planning, and program development

Contributions were made to a report to Agriculture Ministers on Soil and Water Conservation and Development under a charge from the First Ministers' Conference. This involved consultations in all provinces and resulted in major recommendations to achieve long-term sustainment of Canadian agriculture. Subsequently, preparation of a Soil and Water Strategy was begun as part of the National Agricultural Strategy initiated by First Ministers. A related activity was a keynote presentation to a national conference "In search of soil conservation strategies for Canada" in Saskatoon, sponsored by the Agriculture Institute of Canada and other agencies.

Information was gathered for program planning and development by meeting with over half the scientists involved in natural resources research and inventory at establishments from coast to coast. Research needs were analyzed in relation to the evolving strategies and provincial priorities and justification was presented for reallocation of resources to high priority land resources research, evaluation, and surveys.

Natural resources staff were involved in plans to structure departmental research programs in line with the recent Cabinet decision on Technology Centre policy.

Interbranch and interdepartmental activities

Research Branch and the department were represented on various interjurisdictional forums, including the Interdepartmental Committee on Land (ICL) and the Interdepartmental Committee on Water (ICW). Participation on the ICW Mandate Review Committee assisted in restructuring that committee to make it more effective in coordinating federal water programs. Participation on the ICW Water Quality Subcommittee consisted of coordinating input of Agriculture Canada expertise in the preparation of new Water Quality Guidelines for Canada.

Agricultural interests were also represented on the Nonpoint Source Subcommittee of the Great Lakes Water Quality Board, which is primarily concerned about toxic substances and phosphorus from farmland.

A position was prepared on branch soil survey operations in response to the Ministerial Task Force on Major Surveys. This resulted in proper consideration of Agriculture Canada interests in three Memoranda to Cabinet dealing with new policy initiatives for surveys in the federal government.

The issues of impact of Long Range Transport of Air Pollutants were evaluated through participation on the interdepartmental committee on this subject. Specialists collaborated with the Atmospheric Environment Service on studies of climatic change to assess the long-term impact of the "greenhouse effect" on Canadian agriculture. Universities and the international community also participated.

The directorate participated in the development of the Canadian space program and supported the activities of the Interdepartmental Committee on Space.

Responsibilities were also assumed on other interdepartmental committees for coordinating science programs in biotechnolgy and energy. Bilateral meetings were organized with MOSST on the development and implementation of the "Decision framework," which provides new guidelines for the Science and Technology Strategy.

Support to CASCC

In addition to the normal assessment of research needs under CASCC committees and the review of its research recommendations, a secretariat function was provided to the Canada Committee on Land Resource Services. This included publication, with the financial support of CARC, of a report entitled *Land: A fragile resource: New goals for agricultural land research*. This report has been in high demand and provides a basis for setting research priorities.

Extramural activities

A presentation of the national perspective was made to a strategic planning conference for soil and water programs in the Ontario Ministry of Agriculture and Food.

Contributions were also made to the development of the departmental response to an Order in Council that initiated new environmental impact assessment procedures within the federal government.

Discussions were held in England and Germany on research coordination, priority setting, and privatization of soil surveys and research.

ANIMAL AND CROP PROTECTION

Input to policy, planning, and program development

As a follow-up to the work planning meeting on pest management held in Mont Sainte-Marie in 1985, a Workshop on Biological Control was held in Winnipeg on 9–10 October 1986. Thirty-six participants from federal and provincial departments, universities, and the private sector were present. More than 40 recommendations were made concerning enhancement of the use of biological control methods in integrated pest management (IPM) systems; factors affecting the feasibility of the biological control approach; a National Advisory Committee on Biological Control; funding for Commonwealth Institute of Biological Control (CIBC) projects and other sources of imported biological control material; the need to amend or enhance legislation; major constraints affecting augmentation and inundation; research on genetic resistance; research on the use of microorganisms for biological control; means to accelerate the development of biopesticides.

A Workshop on Integrated Pest Management (IPM) in apple orchards was also held at Saint-Jean-sur-Richelieu Research Station, 25–26 November 1986. Nineteen participants from Agriculture Canada, provincial departments, and the private sector from Nova Scotia, Quebec, Ontario, and British Columbia were present. The need for better communication, coordination, and planning at the regional and national levels was stressed by the participants. Increased technical support, increased funds for travel, and the need to maintain a core of expertise in key disciplines were identified as high priorities.

Interbranch and interdepartmental activities

The Research Branch was represented by the Program Coordination Directorate (PCD) on the Federal–Provincial Task Force on Research and Technology Transfer, contributing to the report to the Ministers Responsible for Agriculture in Canada, and the development of a National Agriculture Strategy.

The directorate provided input into the Audit and Evaluation Branch's plant health and input assurance evaluation study and into the evaluation of the future role of the Federal Interdepartmental Committee on Pesticides.

Support to CASCC

PCD provided leadership for the Expert Committee on Insect Pests of Animals, which reviewed and recommended future research needs and priorities for biting fly research in Canada.

Extramural activities

In its role of providing liaison for Commonwealth Agricultural Bureaux (CAB) International, the directorate provided leadership in reviewing Canada's participation in the organization and cooperation with the Commonwealth Institute of Biological Control.

In cooperation with the Canadian Association of Professional Apiculturists (CAPA) and the Canadian Honey Council (CHC), an Apiculture Research Workshop was held in Charlottetown, 17–18 November 1986 to review priorities for research and formulate action plans. Recommendations were made concerning the need for research on bee diseases and pests, bee supply, colony management, stock improvement, pollination–pesticide interactions, and bee botany.

FOOD RESEARCH

Input to policy, planning, and program development

A work planning meeting on meat quality, jointly sponsored by Food Production and Inspection Branch and Research Branch, was held in Winnipeg in October. About half of the 50 participants represented the private sector. Recommendations that will guide the direction of research in meat quality were developed and prioritized.

An evaluation of the food research program was conducted by the Audit and Evaluation Branch. The research coordinator served on the Program Evaluation Review Group and worked closely with the evaluation team, serving as a contact with the research establishments.

The PCD personnel provided leadership in the development of a human resource plan for the Research Branch.

Support to CASCC

In addition to the normal consultations under CASCC and its research recommendations, the secretarial function was provided by Program Coordination Directorate to the Canada Committee on Food.

Interbranch and interdepartmental activities

Program Coordination Directorate assisted on the departmental reviews of nonmission activities by serving on the Task Force on Personnel and Training.

Extramural activities

An invited review paper on food texture was presented at the University of Nottingham's Easter School Series in Agricultural Science.

INTERNATIONAL RESEARCH AND DEVELOPMENT

Research Branch scientists maintain a vigorous program of international science and technology exchanges with agricultural researchers around the world. The branch also supports departmental objectives in the development, maintenance, and expansion of export markets by providing technical expertise to other branches and agencies. In addition, the branch contributes to technological advancement in less-developed countries by having its managers and research staff participate in Canadian development assistance programs and by training foreign scientists in branch establishments.

In 1986, all these activities were coordinated across the branch by the international research and development component of the Program Coordination Directorate. Bilateral and multilateral relations were coordinated with some 55 countries and international agencies in order to enhance our domestic research capability and to ensure that Canadian government policies on agricultural science and technology are supported and encouraged internationally.

Highlights of international coordination during the year included a new round of formal consultations with France and Japan for collaborative research projects under agreements between the Government of Canada and the governments of these countries, for exchange of science and technology. In total, branch activities under some 15 formal agreements or memoranda of understanding with other countries were monitored and coordinated in the directorate.

The branch hosted the 1986 Tetrapartite Meeting of national agricultural research directors from the United Kingdom, United States, France, and Canada. The meeting in Ottawa coincided with the branch centennial celebrations.

The directorate also organized and hosted, on behalf of Canada, the mid-term meeting of the Consultative Group on International Agricultural Research (CGIAR). Some 40 donor countries and agencies of the CGIAR were represented at the meeting in the Government Conference Centre in Ottawa. The program began with a special 1-day Agriculture Canada presentation at the Central Experimental Farm on Canadian scientific and technical contributions to international agricultural research.

Branch involvement in official development assistance programs continue to be coordinated by the directorate. In 1986, the branch was responsible for the management of 10 official development projects in six countries, funded by the Canadian International Development Agency (CIDA). Branch scientists also provided expertise for a wide range of other foreign activities to CIDA and the International Development Research Centre (IDRC).

Branch specialists continued throughout the year to tackle various technical issues related to the international marketing of Canadian agricultural products, and to lend expert support to promotional activities, such as technical seminars and trade expositions, in priority countries with potential for expanded markets for Canadian agriculture.

All of these activities were coordinated through the Program Coordination Directorate.

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RESEARCH BRANCH REPORT

1986

RAPPORT DE LA DIRECTION GÉNÉRALE DE LA RECHERCHE

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Canada

One hundred years of progress

The year 1986 is the centennial of the Research Branch, Agriculture Canada.

On 2 June 1886, *The Experimental Farm Station Act* received Royal Assent. The passage of this legislation marked the creation of the first five experimental farms located at Nappan, Nova Scotia; Ottawa, Ontario; Brandon, Manitoba; Indian Head, Saskatchewan (then called the North-West Territories); and Agassiz, British Columbia. From this beginning has grown the current system of over forty research establishments that stretch from St. John's West, Newfoundland, to Saanichton, British Columbia.

The original experimental farms were established to serve the farming community and assist the Canadian agricultural industry during its early development. Today, the Research Branch continues to search for new technology that will ensure the development and maintenance of a competitive agri-food industry.

Research programs focus on soil management, crop and animal productivity, protection and resource utilization, biotechnology, and food processing and quality.

Cent ans de progrès

En 1986, la Direction générale de la recherche d'Agriculture Canada célèbre ses cent ans d'existence.

C'est, en effet, le 2 juin 1886 que la loi appelée *Acte des stations agronomiques* reçut la sanction royale. De son adoption découla la mise sur pied des cinq premières fermes expérimentales situées à: Nappan, en Nouvelle-Écosse; Ottawa, en Ontario; Brandon, au Manitoba; Indian Head, en Saskatchewan (alors englobée dans les Territoires du Nord-Ouest); et Agassiz, en Colombie-Britannique. C'étaient là les débuts du réseau actuel de plus de quarante établissements de recherches disséminés entre St. John's, à Terre-Neuve, et Saanichton, en Colombie-Britannique.

Les premières stations agronomiques avaient été fondées pour desservir la communauté des agriculteurs et venir en aide au secteur agricole canadien encore débutant. De nos jours, la Direction générale de la recherche poursuit la même tâche en travaillant aux découvertes technologiques dont dépendent le développement et le maintien d'un secteur agro-alimentaire compétitif.

Les programmes de recherches s'intéressent surtout aux modes d'exploitation du sol, à la production animale et végétale, à la protection des richesses naturelles et à leur gestion, aux biotechnologies et enfin à la transformation et à la qualité des aliments.

Research Branch Report

1986

Rapport de la Direction générale de la recherche

RESEARCH BRANCH
DIRECTION GÉNÉRALE DE LA RECHERCHE

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FOREWORD

During 1986, the Research Branch of Agriculture Canada celebrated its centenary.

The *Research Branch Report*, which is published yearly, provides a summary of research results achieved during the year throughout the branch. During 1986, the regions and research centres of the branch effectively contributed to departmental objectives and strategies aimed at enhancing growth, stability, and competitiveness in the agri-food sector. Results are reported in both scientific and extension-type papers. Those for 1986 are listed at the end of each station's report. Information is passed on through various provincial committees and technology transfer mechanisms to the producers and food processors.

The regions of the Research Branch, namely Atlantic, Quebec, Ontario, Central Experimental Farm, Prairie, and Pacific, include 29 major establishments, 13 experimental farms, and a number of smaller units. Each one carries out research contributing to national and regional objectives while developing technology pertinent to the specific area where it is located. The Central Experimental Farm Region in Ottawa, made up of six research centres, combines research on national programs with special services to regional establishments and the public. The Program Coordination Directorate, located at Branch Headquarters in Ottawa, coordinates research programs at the national level and develops policies consistent with furthering the objectives of the branch and the department.

Research programs in the branch are developed in response to the needs of the agri-food industry as determined through the mechanism of the Canadian Agricultural Services Coordinating Committee and consultations at all levels of the agri-food sector.

Research programs encompass all components of the industry, including natural resources, animal and crop production, protection, food processing, nutrition, and food safety. To support these programs, basic research is conducted on such high-priority areas as biotechnology and toxic chemicals.

In 1986, the Research Branch had a budget of $240 million and a staff of 3577, of which 936 were professionals.

The Research Branch cooperates with other branches of Agriculture Canada, with other federal departments, and with various agencies in activities related to the agri-food sector. In 1986 the Research Branch actively participated in the departmental restructuring activities toward market-oriented commodity-based development strategies.

The Research Branch has ongoing science and technology exchanges with several countries, including seven with whom Agriculture Canada has memoranda of understanding and another nine with whom there are other formal arrangements for exchange. Scientific and technical information and personnel are provided to development assistance projects overseas, including the management and staffing of long-term development projects sponsored by the Canadian International Development Agency (CIDA).

This report documents the continuous effort by Research Branch staff to deliver a broad and effective research program that benefits all sectors of the agri-food industry.

E.J. LeRoux
Assistant Deputy Minister, Research

AVANT-PROPOS

En 1986, la Direction generale de la recherche d'Agriculture Canada celébrait son centenaire.

Le Rapport de la Direction générale de la recherche, publié annuellement, présente un résumé des résultats de recherches obtenus au cours de l'année par la Direction générale. En 1986, les régions et les centres de recherches qui relevaient de cet organisme ont contribué efficacement à la réalisation des objectifs et des stratégies du Ministere visant à accroître l'essor, la stabilité et la compétitivité du secteur agro-alimentaire. La Direction générale publie aussi ces résultats dans des rapports scientifiques et des bulletins de vulgarisation. Le répertoire des documents publiés en 1986 paraît à la fin du rapport de chaque station. La Direction générale diffuse l'information par le biais de divers comités provinciaux et de mécanismes de transfert de la technologie aux producteurs et aux transformateurs d'aliments.

Les régions relevant de la Direction generale, soit les provinces de l'Atlantique, le Québec, l'Ontario, la Ferme experimentale centrale, les Prairies et la Région du Pacifique, regroupent 29 établissements d'importance, 13 fermes expérimentales et un certain nombre de centres secondaires. Chaque etablissement mène des recherches en vue d'atteindre les objectifs nationaux et regionaux tout en adaptant des techniques aux besoins particuliers de la région où ils sont situés. La Région de la Ferme experimentale centrale a Ottawa compte six centres de recherches, regroupe les programmes nationaux et offre des services spécialisés aux établissements régionaux et au public. La Direction de la coordination des programmes, située a l'Administration centrale à Ottawa, coordonne les programmes de recherches à l'echelle nationale et élabore des politiques qui s'harmonisent avec les objectifs de la Direction générale et du Ministère.

Les gestionnaires de la Direction générale élaborent les programmes de recherches selon les besoins du secteur agro-alimentaire, lesquels sont établis par l'entremise du réseau du Comité de coordination des services agricoles canadiens et a la suite des consultations menees avec tous les intervenants du secteur.

Ces programmes couvrent tous les aspects du secteur agro-alimentaire, notamment les ressources naturelles, les productions animales et végétales, la protection des vegetaux, la transformation et l'innocuité des aliments, ainsi que la nutrition. Pour les appuyer, on mene egalement des recherches fondamentales dans des domaines hautement prioritaires comme la biotechnologie et les produits chimiques toxiques.

En 1986, la Direction generale de la recherche gerait un budget de 240 millions de dollars et des effectifs composes de 3 577 employés, dont 936 professionnels.

La Direction génerale collabore avec d'autres directions generales d'Agriculture Canada, d'autres ministeres fédéraux et divers organismes dont les activités sont liées au secteur agro-alimentaire. En 1986, elle a participé aux activités de restructuration du Ministère, activites fondées sur des stratégies de développement sectoriel axé sur les marchés.

La Direction generale promeut des échanges constants en sciences et en technologie avec plusieurs pays, dont sept avec qui Agriculture Canada a conclu un protocole d'entente, et neuf autres avec lesquels le Ministere a signe des accords officiels. Elle fournit des renseignements scientifiques et techniques, ainsi que du personnel pour des projets d'aide au developpement outre mer, et participe à la gestion et a la dotation de projets de developpement a long terme parraines par l'Agence canadienne de developpement international (ACDI).

Le present rapport souligne les efforts constants déployes par le personnel de la Direction genérale de la recherche en vue d'exécuter un programme de recherches extensif et efficace dont beneficieront tous les intervenants du secteur agro-alimentaire.

E.J. LeRoux

Sous-ministre adjoint à la Recherche

E.J. LeRoux

W. Baier

J.J. Cartier

Y. Martel

J.-J. Jasmin

W.L. Pelton

S.C. Thompson

R.L. Halstead

L.R. Radburn

J.E. Renaud

J.R. Lessard

Headquarters
Administration centrale

BRANCH EXECUTIVE
HAUTE DIRECTION

Assistant Deputy Minister, Research *Sous-ministre adjoint à la Recherche*	E.J. LeRoux, B.A., M.Sc., Ph.D.
Directors General *Directeurs généraux*	
Program Coordination, Acting *Coordination des programmes, intérimaire*	W. Baier, Diplomlandwirt, Dr.Agr., M.Sc.
Central Experimental Farm, Acting *Ferme expérimentale centrale, intérimaire*	J.J. Cartier, B.A., B.Sc., Ph.D.
Atlantic Region *Région de l'Atlantique*	Y. Martel, B.A., B.Sc.(Agr.), Ph.D.
Quebec Region *Région du Québec*	J.-J. Jasmin, B.Sc.(Agr.), M.Sc.
Ontario Region *Région de l'Ontario*	J.J. Cartier, B.A., B.Sc., Ph.D.
Prairie Region *Région des Prairies*	W.L. Pelton, B.S.A., M.S.A., Ph.D.
Pacific Region *Région du Pacifique*	S.C. Thompson, B.Sc., M.S.A., Ph.D.
Special Advisers *Conseillers spéciaux*	
Special Adviser to the ADM *Conseiller spécial du SMA*	R.L. Halstead, B.S.A., Ph.D.
Director, Administration Division *Directeur de la Division de l'administration*	L.R. Radburn, A.C.B.A., R.I.A.
Branch Financial Manager *Gestionnaire financier de la Direction générale*	J.E. Renaud, C.D.
Executive Assistant *Adjoint exécutif*	J.R. Lessard, B.A., B.Sc., M.S., Ph.D.

ADMINISTRATION DIVISION
DIVISION DE L'ADMINISTRATION

Director *Directeur*	L.R. Radburn
Chief, Administration Section *Chef de la Section de l'administration*	I.M. Wood
Chief, Personnel Section *Chef de la Section du personnel*	G.J. Redmond

BRANCH FINANCIAL MANAGEMENT
GESTION FINANCIÈRE DE LA DIRECTION GÉNÉRALE

Manager *Gestionnaire*	J.E. Renaud,[1] C.D.
Chief, Financial planning *Chef de la Planification financière*	A.L. Dignard[1]
Chief, Financial analysis *Chef de l'Analyse financière*	G. McKane,[1] B.A., C.M.A.
Chief, Financial planning and analysis (CEF and Ontario) *Chef de la Planification et de l'Analyse financières (FEC et Ontario)*	J. B. Moran[1]

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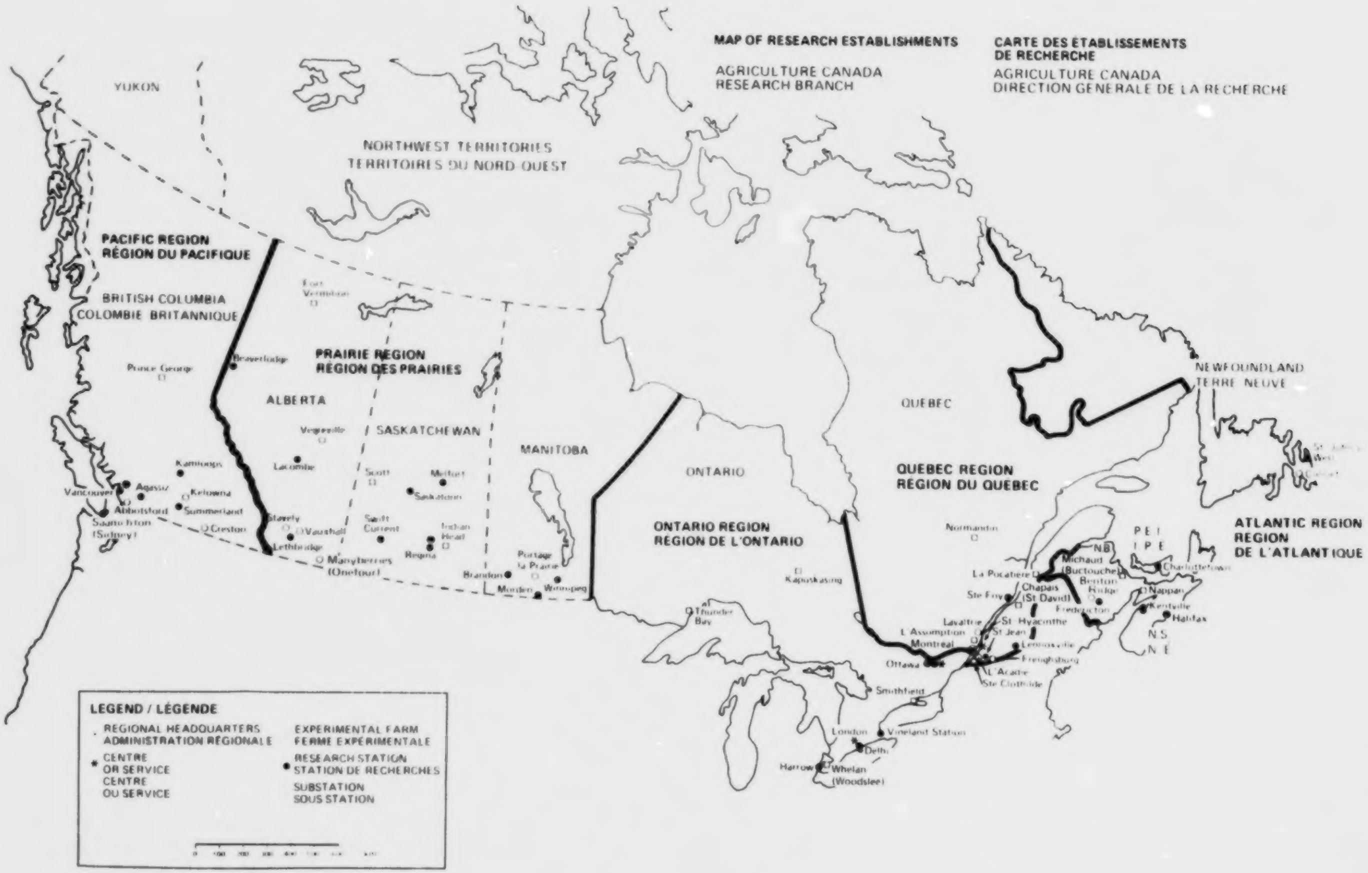
[1] **Seconded from Corporate Management Branch** *Détaché de la Direction générale de la gestion intégrée.*



MAP OF RESEARCH ESTABLISHMENTS

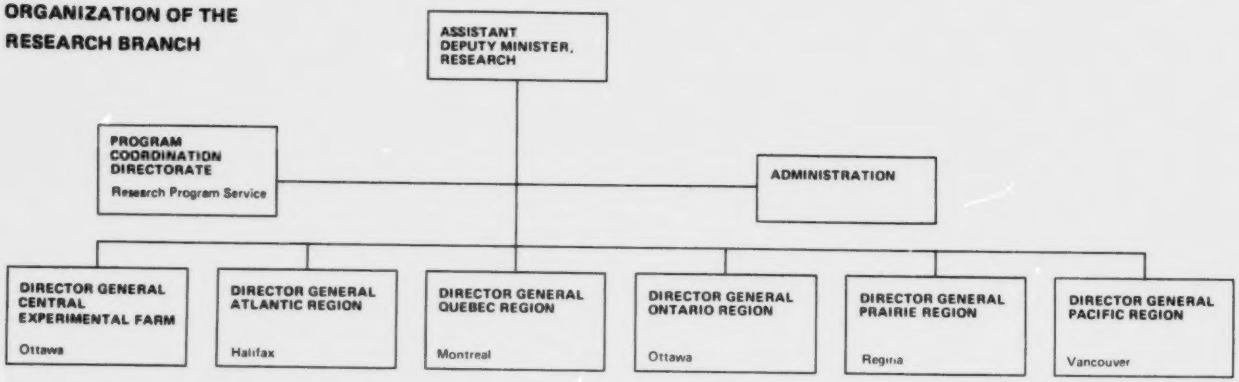
AGRICULTURE CANADA
RESEARCH BRANCH

CARTE DES ÉTABLISSEMENTS DE RECHERCHE

AGRICULTURE CANADA
DIRECTION GENERALE DE LA RECHERCHE

YUKON
NORTHWEST TERRITORIES
TERRITOIRES DU NORD-OUEST
PACIFIC REGION
RÉGION DU PACIFIQUE
BRITISH COLUMBIA
COLOMBIE BRITANNIQUE
Prince George
Kamloops
Agassiz
Vancouver
Kelowna
Abbotsford
Summerland
Saanichton
(Sidney)
Creston
Beaverlodge
Fort Vermilion
PRAIRIE REGION
RÉGION DES PRAIRIES
ALBERTA
Vegreville
Lacombe
Stavely
Vauxhall
Lethbridge
Manyberries
(Onefour)
SASKATCHEWAN
Scott
Melfort
Saskatoon
Swift Current
Indian Head
Regina
MANITOBA
Brandon
Portage la Prairie
Morden
Winnipeg
ONTARIO
ONTARIO REGION
RÉGION DE L'ONTARIO
Thunder Bay
Kapuskasing
Ottawa
Smithfield
London
Vineland Station
Delhi
Harrow
Whelan
(Woodslee)
QUEBEC
QUEBEC REGION
RÉGION DU QUEBEC
Normandin
La Pocatière
Ste Foy
Chapais
(St David)
Lavaltrie
St Hyacinthe
L'Assomption
St Jean
Montreal
Lennoxville
Frelighsburg
L'Acadie
Ste Clothilde
NB
Michaud
(Buctouche)
Benton Ridge
Fredericton
P E I
I P E
Charlottetown
Nappan
Kentville
Halifax
N S
N E
NEWFOUNDLAND
TERRE NEUVE
ATLANTIC REGION
REGION
DE L'ATLANTIQUE
LEGEND / LÉGENDE
REGIONAL HEADQUARTERS
ADMINISTRATION RÉGIONALE
CENTRE
OR SERVICE
CENTRE
OU SERVICE
EXPERIMENTAL FARM
FERME EXPÉRIMENTALE
RESEARCH STATION
STATION DE RECHERCHES
SUBSTATION
SOUS STATION

ORGANIZATION OF THE RESEARCH BRANCH


ASSISTANT DEPUTY MINISTER, RESEARCH
PROGRAM COORDINATION DIRECTORATE
Research Program Service
ADMINISTRATION
DIRECTOR GENERAL CENTRAL EXPERIMENTAL FARM
Ottawa
DIRECTOR GENERAL ATLANTIC REGION
Halifax
DIRECTOR GENERAL QUEBEC REGION
Montreal
DIRECTOR GENERAL ONTARIO REGION
Ottawa
DIRECTOR GENERAL PRAIRIE REGION
Regina
DIRECTOR GENERAL PACIFIC REGION
Vancouver

Research Centres

- Animal
- Biosystematics
- Engineering and Statistical
- Land Resource
- Plant

Research Stations

- St. John's West, Nfld.
  - Colinet, Nfld.
- Charlottetown, P.E.I.
- Kentville, N.S.
  - Nappan, N.S.
- Fredericton, N.B.
  - Benton Ridge, N.B.
  - Michaud (Buctouche), N.B.

Research Centre

- Food, Saint-Hyacinthe, Que.

Research Stations

- Lennoxville, Que.
- Sainte-Foy, Que.
  - La Pocatière, Que.
  - Normandin, Que.
  - Chapais (Saint-David), Que.
- Saint-Jean, Que.
  - Frelighsburg, Que.
  - L'Acadie, Que.
  - L'Assomption, Que.
  - Lavaltrie, Que.
  - Sainte-Clothilde, Que.

Research Centres

- Food, Ottawa, Ont.
- London, Ont.

Research Stations

- Delhi, Ont.
- Harrow, Ont.
  - Whelan (Woodslee), Ont.
- Vineland Station, Ont.
  - Smithfield, Ont.

Experimental Farm

- Kapuskasing, Ont.
  - Thunder Bay, Ont.

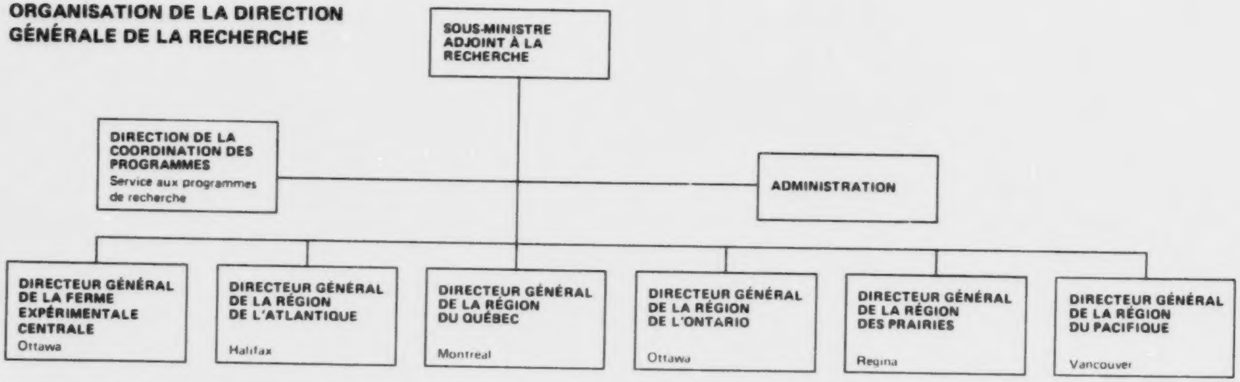
Research Stations

- Brandon, Man.
- Morden, Man.
  - Portage la Prairie, Man.
- Winnipeg, Man.
- Melfort, Sask.
- Regina, Sask.
  - Indian Head, Sask.
- Saskatoon, Sask.
  - Scott, Sask.
- Swift Current, Sask.
- Beaverlodge, Alta.
  - Fort Vermilion, Alta.
- Lacombe, Alta.
  - Vegreville, Alta.
- Lethbridge, Alta.
  - Manyberries (Onefour), Alta.
  - Stavely, Alta.
  - Vauxhall, Alta.

Research Stations

- Agassiz, B.C.
  - Abbotsford, B.C.
- Kamloops, B.C.
  - Prince George, B.C.
- Saanichton Research and Plant Quarantine Station (Sidney), B.C.
- Summerland, B.C.
  - Creston, B.C.
  - Kelowna, B.C.
- Vancouver, B.C.

ORGANISATION DE LA DIRECTION GÉNÉRALE DE LA RECHERCHE


SOUS-MINISTRE ADJOINT À LA RECHERCHE
DIRECTION DE LA COORDINATION DES PROGRAMMES
Service aux programmes de recherche
ADMINISTRATION
DIRECTEUR GÉNÉRAL DE LA FERME EXPÉRIMENTALE CENTRALE
Ottawa
DIRECTEUR GÉNÉRAL DE LA RÉGION DE L'ATLANTIQUE
Halifax
DIRECTEUR GÉNÉRAL DE LA RÉGION DU QUÉBEC
Montreal
DIRECTEUR GÉNÉRAL DE LA RÉGION DE L'ONTARIO
Ottawa
DIRECTEUR GÉNÉRAL DE LA RÉGION DES PRAIRIES
Regina
DIRECTEUR GÉNÉRAL DE LA RÉGION DU PACIFIQUE
Vancouver

Centres de recherches

Biosystématique
Phytotechniques
Technique et statistique
Terres
Zootechnie

Stations de recherches

Saint-Jean (T.-N.)
  Colinet (T.-N.)
Charlottetown (Î.-P.-E.)
Kentville (N.-E.)
  Nappan (N.-E.)
Fredericton (N.-B.)
  Benton Ridge (N.-B.)
  Michaud
    (Buctouche) (N.-B.)

Centre de recherches

Aliments
  (Saint-Hyacinthe)
  (Quebec)

Stations de recherches

Lennoxville (Québec)
Sainte-Foy (Québec)
  La Pocatière (Quebec)
  Normandin (Quebec)
  Chapais
    (Saint-David) (Quebec)
Saint-Jean (Quebec)
  Frelighsburg (Québec)
  L'Acadie (Quebec)
  L'Assomption (Québec)
  Lavaltrie (Quebec)
  Sainte-Clothilde (Quebec)

Centres de recherches

Aliments (Ottawa)(Ont.)
London (Ont.)

Stations de recherches

Delhi (Ont.)
Harrow (Ont.)
  Whelan
    (Woodslee), (Ont.)
Vineland Station (Ont.)
  Smithfield (Ont.)

Ferme expérimentale

Kapuskasing (Ont.)
  Thunder Bay (Ont.)

Stations de recherches

Brandon (Man.)
Morden (Man.)
  Portage la Prairie (Man.)
Winnipeg (Man.)
Melfort (Sask.)
Regina (Sask.)
  Indian Head (Sask.)
Saskatoon (Sask.)
  Scott (Sask.)
Swift Current (Sask.)
Beaverlodge (Alb.)
  Fort Vermilion (Alb.)
Lacombe (Alb.)
  Vegreville (Alb.)
Lethbridge (Alb.)
  Manyberries
    (Onefour) (Alb.)
  Stavely (Alb.)
  Vauxhall (Alb.)

Stations de recherches

Agassiz (C.-B.)
  Abbotsford (C.-B.)
Kamloops (C.-B.)
  Prince George (C.-B.)
  Station de recherches et de quarantaine des plantes de Saanichton (Sidney) (C.-B.)
Summerland (C.-B.)
  Creston (C.-B.)
  Kelowna (C.-B.)
Vancouver (C.-B.)

PROGRAM STRUCTURE OF THE RESEARCH BRANCH

Departmental objective

Agriculture Canada's objective is to promote the growth, stability, and competitiveness of the agri-food sector, by making available policies, programs, and services that are most appropriately provided by the federal government, so that the sector makes its maximum contribution to the economy.

Branch objective

The Research Branch's objective for the scientific research and development planning element is to maintain and improve the productivity of the agri-food sector through developing and transferring new knowledge and technology.

Objectives for branch planning sub-elements and sub-sub-elements

Management and administration. To provide the managerial, financial, personnel, and administrative services required for efficient management of the Research Branch.

1. Planning and program management
   To provide branch planning and program coordination in support of senior branch management.
2. Administrative services
   To provide support for branch management in financial, personnel, and any other administrative areas necessary for the efficient functioning of the branch.

Resource and support research. To produce scientific and technical information and to develop technology that will assist the agri-food sector in managing and conserving the natural resources necessary for agricultural production, while increasing the level and efficiency of production, and that will assist other researchers in developing applied technology.

1. Land
   To provide accurate information about the quantity, quality, and location of Canada's land resource and to better understand the properties of soils, which affect agricultural productivity.
2. Water and climate
   To improve water management on Canadian soils in order to increase productivity and to monitor and preserve environmental quality within the constraints imposed by Canada's northern climate.
3. Energy and engineering
   To develop and adapt engineering technology that will optimize energy utilization and efficiency of production, storage, processing, and distribution of agricultural products.
4. Biological resources
   To provide accurate information about the quantity, quality, and location of Canada's biological resources (including vascular plants, insects, arachnids, nematodes, fungi, and bacteria) and to provide identification services that can be used as required to ensure agricultural productivity.
5. Biotechnology
   To assess, develop, and utilize technology in support of basic and applied agricultural research.
6. Protection
   To provide new, general, and basic research information on the protection of animals and crops from diseases, insects, and weeds.
7. Scientific support services
   To provide for all scientific researchers the statistical, graphic arts, publishing, and other general support services necessary to maintain the quality and quantity of output of research findings.

Animal productivity research. To produce scientific and technical information and develop new technology that will assist the primary producer in increasing the quality and efficiency of the production of animals.

1. Beef
   To improve the efficiency of beef production and the quality of beef products in support of regional, domestic, and export market development.
2. Dairy
   To improve the efficiency of milk production for domestic and export market development.

3. Swine
To improve the efficiency of pork production and the quality of pork and pork products in support of domestic and export market development.

4. Poultry
To improve the efficiency of production of eggs and poultry meat and the quality of poultry products in support of domestic and export market development.

5. Other animals
To increase the efficiency of production and quality of products from sheep, honey bees, fur bearers, and any other animals deemed to be of agricultural importance in support of domestic and export market development.

Crop productivity research. To produce scientific and technical information and develop new technology that will assist the primary producer in increasing the quality and efficiency of the production of crops.

1. Cereals
To increase the production efficiency, quality, and protection of cereal crops for domestic and export markets.

2. Oilseeds
To increase the efficiency of production adaptability and the quality of oilseed crops and their products for domestic and export markets.

3. Forages
To increase the efficiency of production adaptability and the quality of domestic forage crops in support of livestock production.

4. Field crops
To increase the production efficiency, quality, and protection of field crops such as tobacco, field peas, buckwheat, and field beans.

5. Vegetables
To increase the efficiency of production, protection, adaptability, and quality of vegetables for the domestic market, and of potatoes and seed potatoes for export.

6. Tree fruits and berries
To increase the efficiency of production, protection, adaptability, and quality of tree fruits and berries for domestic and export markets.

7. Ornamentals
To develop, test, and release high-quality ornamental plants that are adapted to Canada's climatic regions.

Food research. To produce scientific and technical information and develop technology that will assist the agri-food processing sector in increasing the efficiency and effectiveness of crop and animal commodity processing, while ensuring the safety and nutritional value of food.

1. Food processing equipment and products
To develop new food-processing technology, to improve the efficiency and effectiveness of food-processing systems, and to develop and characterize new uses of products and ingredients from agricultural crops and animal products.

2. Food safety and nutrition
To increase consumer safety from antinutritional and toxic constituents in food and to monitor and improve the nutritive value of agricultural products.

3. Storage
To develop and apply processes and handling procedures for maintaining the quality of foods after crop harvest.

STRUCTURE DU PROGRAMME DE LA DIRECTION GÉNÉRALE DE LA RECHERCHE

Objectif du Ministère

L'objectif d'Agriculture Canada est de promouvoir la croissance, la stabilité et la compétitivité du secteur agro-alimentaire au moyen de politiques, de programmes et de services fournis par le gouvernement fédéral, de façon à assurer une contribution optimale de ce secteur à l'économie.

Objectifs de la Direction générale

L'élément planification de la recherche scientifique et du développement de la Direction générale de la recherche a pour objectif d'améliorer la productivité du secteur agro-alimentaire en mettant au point de nouvelles technologies et en diffusant les connaissances.

Objectifs des sous-divisions et des sub-sous-divisions de la planification

Gestion et administration. Fournir les services nécessaires dans les domaines de la gestion, des finances, du personnel et de l'administration afin d'assurer une gestion efficace de la Direction générale.

1. Planification et gestion des programmes
   Assurer la planification et la coordination des programmes de la Direction générale afin d'appuyer la haute direction.

2. Services administratifs
   Fournir un soutien à la haute direction dans les domaines des finances, du personnel et tout autre domaine administratif pour assurer le bon fonctionnement de la Direction générale.

Recherche sur les ressources et recherche de soutien. Mettre à la disposition du secteur agro-alimentaire des informations scientifiques et techniques et développer des technologies qui l'aideront à gérer et à conserver les ressources naturelles nécessaires à la production agricole tout en augmentant leur utilisation efficace: ces mêmes ressources doivent aider les chercheurs à mettre au point des technologies appliquées.

1. Terres
   Fournir des informations précises sur la quantité, la qualité et l'emplacement des ressources en terres du Canada et parvenir à une meilleure connaissance des propriétés des sols, qui influent sur la productivité agricole.

2. Eau et climat
   Améliorer la gestion des eaux sur les sols du Canada afin d'accroître la productivité et de contrôler et conserver la qualité de l'environnement, en tenant compte des contraintes imposées par le climat boréal du Canada.

3. Énergie et recherches techniques
   Développer et adapter une technologie pour optimiser le rendement énergétique et l'efficacité de la production, du stockage, de la transformation et de la distribution des produits agricoles.

4. Ressources biologiques
   Fournir des informations précises sur la quantité, la qualité et l'emplacement des ressources biologiques du Canada (notamment les plantes vasculaires, insectes, arachnides, nématodes, champignons et bactéries) et offrir des services d'identification sur demande pour assurer la productivité agricole.

5. Biotechnologie
   Évaluer, développer et appliquer une technologie à l'appui de la recherche agricole fondamentale et appliquée.

6. Protection
   Fournir les résultats généraux et fondamentaux sur la recherche dans le domaine de la protection des animaux et des récoltes contre les maladies, les insectes et les mauvaises herbes.

7. Services de soutien scientifique
   Fournir à tous les chercheurs des statistiques, des publications et tout autre service d'aide générale nécessaire au maintien de la qualité de la recherche et à l'accroissement de la productivité des opérations.

Recherche sur la production animale. Produire l'information scientifique et technique et élaborer une nouvelle technologie afin d'aider le producteur primaire à augmenter la qualité et l'efficacité de la production animale.

1. Bovins de boucherie
   Accroître l'efficacité de la production bovine et améliorer la qualité des produits pour les marchés régional, national et d'exportation.

2. Bovins laitiers
   Accroître l'efficacité de la production laitière pour les marchés national et d'exportation.

3. Porcs
   Accroître l'efficacité de la production porcine et améliorer la qualité des produits pour les marchés national et d'exportation.

4. Volaille
   Accroître l'efficacité de la production des oeufs et de la volaille et améliorer la qualité des produits avicoles pour les marchés national et d'exportation.

5. Autres
   Accroître l'efficacité de la production ovine, apicole, d'animaux à fourrure et de tous les autres animaux jugés importants pour l'agriculture, pour les marchés national et d'exportation.

Recherche sur les productions végétales. Produire de l'information scientifique et technique et élaborer une nouvelle technologie afin d'aider le producteur primaire à augmenter la qualité et l'efficacité de la production animale.

1. Céréales
   Accroître l'efficacité, la qualité et la protection des cultures céréalières pour les marchés national et d'exportation.
2. Oléagineux
   Accroître l'adaptabilité sur le plan productif et la qualité des oléagineux et de leurs produits pour les marchés national et d'exportation.
3. Fourrages
   Accroître l'adaptabilité sur le plan productif et la qualité des cultures fourragères sur le plan national afin d'aider à la production du bétail.
4. Grandes cultures
   Accroître l'efficacité de la production, la qualité et la protection des grandes cultures comme le tabac, le pois sec, le sarrasin et le haricot sec.
5. Légumes
   Accroître l'efficacité de la production, la protection, l'adaptabilité et la qualité des légumes pour le marché national, et des pommes de terre et des pommes de terre de semence pour l'exportation.
6. Arbres fruitiers et baies
   Accroître l'efficacité de la production, la protection, l'adaptabilité et la qualité des arbres fruitiers et des baies afin d'augmenter les marchés national et d'exportation.
7. Plantes d'ornement
   Développer, tester et distribuer des plantes d'ornement de grande qualité qui soient adaptées aux différentes régions climatiques du Canada.

Recherches alimentaires. Fournir l'information scientifique et technique et élaborer la technologie à l'appui du secteur de la transformation agro-alimentaire afin d'accroître l'efficacité et la rentabilité de la transformation des produits animaux et végétaux tout en assurant la salubrité et la valeur nutritive des aliments produits.

1. Equipement de transformation alimentaire et aliments
   Élaborer de nouvelles techniques de transformation des produits alimentaires, accroître l'efficacité et la rentabilité des systèmes de transformation et élaborer et caractériser de nouvelles façons d'utiliser des produits et ingrédients provenant des cultures et des animaux.
2. Salubrité des aliments et nutrition
   Accroître la protection des consommateurs contre les constituants alimentaires toxiques et néfastes sur le plan nutritif et d'assurer et rehausser la valeur nutritive des produits agricoles.
3. Conservation
   Developper et mettre en pratique des façons de procéder pour maintenir la haute qualité des aliments après la moisson.

Program Coordination Directorate

Direction de la coordination des programmes

W. Baier

R. Bouchard

W.J. Saidak

E. Larmond

C.B. Willis

D.F. Kirkland

G.W. Andrews

G.A. Neish

J. Nowland

Acting Director General *Directeur général, intérimaire*	W. Baier, Diplomlandwirt, Dr.Agr., M.Sc.

Research Coordinators *Coordonnateurs des recherches*

Animal production *Production des animaux*	R. Bouchard, B.A., B.S.A., M.Sc., Ph.D.
Crop production (grains and oilseeds) *Production végétale (céréales et oleagineux)*	W.J. Saidak, B.S.A., M.S., Ph.D., F.W.S.S.A.
Food *Aliments*	E. Larmond, B.Sc.
Crop production (horticulture and special crops) *Production végétale (horticulture et cultures spéciales)*	C.B. Willis, B.Sc.(Agr.), Ph.D., F.A.I.C.
International R & D, acting *R & D international, intérimaire*	D.F. Kirkland
Planning and policy *Planification et politique*	G.W. Andrews, B.Sc.F., M.Sc.
Protection, acting *Protection, intérimaire*	G.A. Neish, B.Sc., Ph.D.
Natural Resources *Ressources naturelles*	J. Nowland, B.A., M.Sc.

PREFACE

The Program Coordination Directorate (PCD) provides the Research Branch with a national capability for coordinating agricultural research in Canada. The directorate is an essential component of Research Branch management. It ensures that research programs achieve maximum contribution to the department's scientific endeavors in support of the agri-food industry. It is the only group without regional affiliation, with specific responsibility for the national branch strategy as a whole.

PCD provides expertise in agricultural research at Research Branch Headquarters in Ottawa, supporting the Assistant Deputy Minister, Research, in his roles as both branch head and corporate manager. Through consultation and advice PCD assists in the management of research programs and in the development and implementation of branch and departmental policies. It is also called upon to assist in the analysis of government policies that have an impact upon the branch and the department. In performing these advisory duties, PCD is responsible for preparing briefings, position papers, and correspondence relating to any of these topics.

PCD plans national programs through the consolidation of regional operational plans. The directorate also reviews the effectiveness of programs in meeting objectives and determines the impact of programs on the agri-food sector. It coordinates at the national level the scientifically based activities that result in the monitoring and delivery of programs at the regional level. It is the principal contact on matters concerning research and development (R&D) with central agencies, other countries, departments, provinces, universities, and industry. It effects liaison between the Research Branch and other branches, departments, and agencies leading to collaborative action on national (e.g., Economic Regional Development Agreement) and international (e.g., CIDA) matters. It is responsible for the organization of the activities of the Canadian Agricultural Services Coordinating Committee (CASCC) and the Canadian Agricultural Research Council (CARC). Under the Research Branch's human resources development plan, the directorate provides training for potential managers.

Currently, PCD consists of the director general and eight coordinators, all of whom are senior professionals with international recognition in their specific disciplines. The group also includes one special adviser and one special assistant (CASCC and CARC), who provide support on a permanent basis. In addition, six professionals are seconded to the directorate as special advisers.

The current divisions of responsibility within the group are policy and planning, crop and animal production, protection, natural resources, food, and international R&D.

W. Baier
Acting Director General

PRÉFACE

La Direction de la coordination des programmes (DCP) offre à la Direction générale de la recherche des services de coordination nationale de la recherche agricole au Canada. Elle constitue un élément essentiel de gestion pour la Direction générale. Elle veille à ce que les programmes de recherches contribuent le plus possible à l'aboutissement des efforts scientifiques que déploie le Ministère pour le bénéfice du secteur agro-alimentaire. C'est le seul organisme sans affiliation régionale et dont la responsabilité unique consiste à appliquer globalement la stratégie nationale de la Direction générale.

La DCP dispense des services d'experts-conseils en recherche agricole à l'Administration centrale de la Direction générale de la recherche à Ottawa. Le Sous-ministre adjoint à la Recherche peut donc compter sur ceci pour remplir à la fois son double rôle de chef de la Direction générale et de cadre ministériel. En effet, par le biais du processus de consultation et d'information, la DCP appuie la gestion des programmes de recherches, ainsi que l'élaboration et l'application des politiques de la Direction générale et du Ministère. On fait également appel à ses services pour l'analyse des politiques gouvernementales qui touchent à la Direction générale et au Ministère. En raison des services consultatifs qu'elle offre, le personnel de la DCP doit préparer des notes d'information, des exposés de principes et de la correspondance sur n'importe lequel de ces sujets.

La Direction planifie également les programmes nationaux en regroupant les plans opérationnels régionaux. Elle vérifie en outre l'efficacité des programmes par rapport aux objectifs établis et détermine leur incidence sur le secteur agro-alimentaire. Elle coordonne, à l'échelle nationale, les activités scientifiques touchant à la surveillance et à l'exécution des programmes à l'échelle régionale. La Direction sert d'organe de liaison principal avec les organismes centraux, les autres ministères, les provinces, les universités et les représentants de la profession et des autres pays pour les questions de recherche et de développement. Elle établit des liens entre la Direction générale de la recherche et les autres directions générales, ministères et organismes afin de favoriser une meilleure concertation à l'égard des questions de portée nationale (p. ex., Entente de développement économique et régional) et internationale (p. ex., ACDI). Elle s'occupe également des activités du Comité de coordination des services agricoles canadiens (CCSAC) et du Conseil de recherches agricoles du Canada (CRAC). Par ailleurs, dans le cadre du programme de perfectionnement des ressources humaines de la Direction générale, la Direction assure la formation des futurs gestionnaires.

Actuellement, la DCP se compose du directeur général et de huit coordonnateurs, qui sont des professionnels-cadres de renommée internationale dans leur domaine respectif. Le groupe jouit également du soutien permanent d'un conseiller spécial et d'un adjoint particulier (CCSAC et CRAC). En outre, six autres professionnels sont détachés à la Direction en qualité de conseillers spéciaux.

Les divers services d'experts offerts par la Direction portent sur les politiques et la planification, les productions animales et végétales, la protection des ressources, les ressources naturelles, l'alimentation, ainsi que la recherche et le développement au niveau international.

W. Baier

Le Directeur général intérimaire

Program Coordination Directorate
Ottawa, Ontario

PROFESSIONAL STAFF

W. Baier, Diplomlandwirt, Dr.Agr., M.Sc.	Acting Director General

Research Coordinators

G.W. Andrews,[1] B.Sc.F., M.Sc.	Planning and policy
R. Bouchard, B.A., B.S.A., M.Sc., Ph.D.	Animal production
D.F. Kirkland	International R&D, acting
E. Larmond,[2] B.Sc.	Food
G.A. Neish,[3] B.Sc., Ph.D.	Protection, acting
J. Nowland, B.A., M.Sc.	Natural resources
W.J. Saidak, B.S.A., M.S., Ph.D., F.W.S.S.A.	Crop production – grains and oilseeds
C.B. Willis, B.Sc.(Agr.), Ph.D., F.A.I.C.	Crop production – horticulture and special crops

Special Adviser

M.K. John, B.Sc.(Agr.), M.Sc., Ph.D.	Resources

Secondees/Trainees

B.B. Chubey,[4] B.S.A., M.Sc., Ph.D.	Horticulture and special crops
A.M. B. de Passillé,[5] B.Sc., M.Sc.	Animal production
A. Ferguson,[6] B.S.A.	Special adviser
B.N.A. Hudson,[7] B.Sc., Ph.D.	Protection
K.W. Lievers,[8] B.Sc., M.Sc.	Industry relations
J.A. Perrin,[9] B.Sc.	Operational processes

Special Assistants, Committees and Special Projects

E. Hunter	CASCC and CARC
B.J. Kealey,[10] B.A.	CASCC and CARC, acting

Departures

D.J.E. Demars, B.Sc., M.Sc., Ph.D. Seconded to Central Experimental Farm Directorate as Program Specialist, February 1986	Human resources planning and industry relations
D.P. Gray, B.Sc., D.V.M., M.V.Sc. Retired July 1986	Animal health and diseases
D.R. Phillips, B.Sc., M.Sc., Ph.D. Transferred to Experimental Farm, Smithfield, Ont., September 1986	International R&D

R. Trottier, B.Sc., M.Sc., Ph.D. Appointed Acting Director, Biosystematics Research Centre, Ottawa, Ont., October 1986	Research Coordinator, Protection
D.F. Wood, B.Sc., M.Sc., Ph.D. Returned to Food Research Centre, Ottawa, Ont., April 1986	Research Coordinator, Food, acting

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[1] Appointed 1 March 1986.

[2] Appointed 20 January 1986.

[3] Seconded from Biosystematics Research Centre, Ottawa, Ont.

[4] Seconded from Research Station, Morden, Man.

[5] Seconded from Research Station, Lennoxville, Que.

[6] Seconded from Food Production and Inspection Branch, Ottawa, Ont.

[7] Seconded from Biosystematics Research Centre, Ottawa, Ont.

[8] Seconded from Engineering and Statistical Research Centre, Ottawa, Ont.

[9] Seconded from Research Program Service, Ottawa, Ont.

[10] Appointed 1 July 1986.

INTRODUCTION

Over the year, the Program Coordination Directorate (PCD) has fulfilled its role as described in the Preface and has also addressed a number of new demands arising from government policy. The 1986 Budget Speech outlined overall fiscal cutbacks, which resulted in the development of a program rationalization strategy for the branch. Nonmission-dedicated resources were carefully examined with a view to identifying areas for further resource reductions. As a result, a decision to centralize branch senior management and associated administration activities was taken, which should result both in an enhanced environment for decision making and in resource savings for the branch.

PCD responded to the recommendations outlined in the Auditor General's report of 1986, which contained a major section on the management of research operations. A human resource management strategy was drafted and guidelines and criteria for project selection and assessment were developed.

New directions for the branch started to emerge toward the end of the year, as increased emphasis began to be placed on industry relations, federal–provincial memoranda of understanding, CASCC–CARC restructuring, and university–industry–provincial partnerships.

W. Baier
Acting Director General

POLICY, PLANNING, AND CONTROL

Response to government initiatives

The Program Coordination Directorate (PCD) addressed the challenge of advising branch management on mechanisms to implement government priorities aimed at resource reduction in a manner that would have the least effect on program delivery. The concern was to ensure a viable research organization to meet the needs of the agri-food industry in a climate of downsizing of resources.

Program rationalization strategy. In response to the fiscal cutbacks outlined in the 1986 Budget Speech, the directorate prepared a program rationalization strategy to accommodate person-year reductions that would assist the department to meet its overall objectives. The strategy identified three program categories: programs to be strengthened, those to be maintained, and those to be consolidated. At the national level, no programs are expected to be eliminated entirely; a core program will be maintained in at least one establishment. Implementation of the strategy will be reviewed to take full advantage of attrition and initiatives such as voluntary retirement schemes.

Nonmission-oriented operations. In 1986, working groups were established to examine all nonmission-dedicated resources, with the goal of identifying further resource savings. The PCD provided major input and support. The major functional areas of personnel and training, information and publishing, co-location, land divestment, finance, administrative services, operational planning, and systems and consulting were reviewed. As a result of studies on regional departmental organizations, the Research Branch concluded that regional restructuring would be a feasible mechanism for achieving resource savings. It was agreed that restructuring would proceed on the basis of three regions: Eastern, Central, and Western, each headed by a director general. The regions would be supported by an expanded Program Coordination Directorate, to be renamed the Priorities and Strategies Directorate. Full implementation is expected to take place on 1 April 1987.

Branch advisory committees

To assist in identifying priority research needs in relation to the market-oriented, commodity-based development strategies, PCD initiated the establishment of branch advisory committees, with membership from across the Research Branch. Their purpose is to engage the expertise of senior research scientists in support of the activities of research coordinators and branch decisions. These committees would examine branch operations in commodity and non-commodity areas for delivery of effective and efficient operational output. In addition, they would support the branch representatives on the commodity teams. The establishment of branch advisory committees was finalized in October 1986 and several are now active.

Program specialists' meeting

The program specialists' meeting, held 4 November 1986, provided an excellent opportunity for regional representatives to meet with members of the directorate on issues of mutual concern, with emphasis on operational and work planning. The Deputy Minister's objectives and priorities, as well as the priority goals for the commodity strategies, were outlined as the basis for work planning in 1987–1988.

Topics discussed included industry relations and collaborative research, cost recovery, commodity strategies, the program strategy for soil and water, and a profile of activities of professional staff. The new departmental planning process was described, noting that a major improvement would be closer involvement by branch heads in strategic issues. Extensive discussion took place on methods to simplify and streamline the establishment work planning process. The procedure agreed upon would provide for one work plan for each branch project (four-digit code) at an establishment, which would consist of an objective, resources, goals, and performance indicators. The need for a clear, concise definition of project was strongly identified, and will be addressed in future discussions relating to the Decision Information Systems Plan.

Operational plan

In preparation for the 1987 branch head operational plan, the Program Coordination Directorate prepared responses to the Deputy Minister's priorities for the coming year under the headings of shared jurisdiction, high-profile issues, facilitating structural adjustment of the sector, and management issues. The responses from all senior managers in the department provided the basis for the compilation of the department strategic directions document. The Research Branch was assigned the lead role in implementing the strategies outlined in the technology enhancement priority. The directorate was responsible for developing the branch priorities and strategies that would address department priorities as well as responding to the recommendations put forward in the National Agriculture Strategy by the ministers responsible for agri-culture in Canada. The 1987 priorities from the commodity development strategies were also taken into consideration.

The resulting branch head operational plan has set the direction for the branch during 1987–1988 and beyond. A major enhancement in this plan is the extensive cooperation that is required among branches in order to achieve the intended results. The Program Coordination Directorate must play a major consultative role to ensure that the cooperative goals are attained.

Human resource planning

In July 1986 the Assistant Deputy Minister, Research, established a committee to develop a Human Resources Plan for the Research Branch, with special attention to research scientists. This action was taken in response to recommendations in the Neilsen Task Force report and the 1986 Auditor General's report. Leadership was provided by the Program Coordination Directorate.

In order to establish a mechanism to determine the needs of the branch for research scientists, two surveys were conducted to determine (*1*) the capabilities of the research scientists now in the branch (supply), and (*2*) the forecast skills required by the branch in 1991 (demand). The supply inventory was completed by individual research scientists. The demand surveys were sent to directors general but in most instances they were completed by establishment directors.

Considerable attention was given to the management of research scientists. Issues that surfaced during consultation were studied by the committee, various options examined, and recommendations proposed. These recommendations aim at ensuring that the scientists in the branch are motivated, challenged, and sufficiently rewarded. The implementation of the plan in 1987 and beyond should ensure that the branch has the necessary scientific human resources and that it uses them in the most efficient manner to carry out its mission.

Operational reporting and control

Decision Information Systems Plan. The branch-wide project entitled "Decision Information Systems Plan" was developed during the first part of the year by a working group made up of branch personnel, specialists from the Corporate Management Branch, and an outside consultant. The aim of the project was to provide a solid base for more efficient and effective information systems as well as a mechanism for operational control. The project included the development of business and information models and an inventory of current data bases and systems. The Program Coordination Directorate played an active role in this project through membership on the working group. Ten sub-projects were identified for implementation as resources become available, with top priority being given to "Project control in stations" and "Establishment accounting."

Project selection and assessment. In response to the Auditor General's recommendation for improved management of research operations, the PCD developed a document entitled "Guidelines and criteria for project selection and assessment." This document provides standard guidance to assist managers in selecting research studies that will respond to the needs of clients as well as relating directly to establishment, branch, and department priorities and objectives.

Reporting to Treasury Board and Parliament. The Program Coordination Directorate prepared the Research Branch sections in two departmental reports to Treasury Board and Parliament: the *Main Estimate Part III* and the *Annual Report of the Minister*. These reports provide an opportunity for the branch to clearly outline its concerns, opportunities, and resource needs for the upcoming fiscal year, and to describe its achievements of the previous year.

Quarterly reporting. The PCD provided leadership in coordinating the preparation of quarterly reports across the branch. The reports at all management levels are prepared according to the structure defined in the Operational Planning Framework. Revised guidelines for regions resulted in the documentation of concise, relevant information with focus on major variances and achievements, allowing for ready amalgamation of pertinent information into the branch head report.

Directors' work planning meeting

A directors' work planning meeting, organized by the Program Coordination Directorate, was held in Ottawa on 2–4 June 1986. The meeting coincided with the centennial celebrations of agricultural research, and the agenda on 2 June included tours of the Central Experimental Farm and attendance at the official centennial ceremonies. The 2nd and 3rd days focused on presentations and discussions aimed at developing ways to continue to make progress in the face of new challenges during and after 1986. Under the theme of management, a number of pertinent topics were addressed: how to manage with commodity strategies, industry relations, how to manage downsizing, opportunities, and problems in personnel management, and the Auditor General's report. The discussions allowed all participants to voice their concerns and offer suggestions. Other presentations dealt with the topics of data bases and the federal–provincial working groups on technology transfer and soil and water issues.

Cost recovery

PCD continued to consider the various possibilities for cost recovery in Research Branch. Although there is pressure to explore all possible sources of revenue in the short term, the branch, by nature of its mandate and the longer time frame required for effective delivery of R&D programs, is focusing its cost recovery efforts on expenditure reduction rather than on revenue generation. In principle, areas of R&D that generate significant revenues should become prime candidates for privatization.

The predominant part of industry related involvement, both current and future, is in collaborative R&D. The current industry support in kind is not translatable into revenue because industry insists on (*1*) controlled and targeted contributions to specific collaborative R&D projects, and (*2*) supplementing rather than subsidizing current levels of research.

Industry relations

The PCD is placing increased emphasis on its interactions with the agri-food industry. With the assistance of senior branch officials, draft policy and guidelines were developed on collaborative R&D with industry, in order to facilitate co-development and transfer of technology. A paper entitled *Industry participation in research priority setting* documents the tremendous involvement that exists with industry at the grass roots level. It also presents recommendations and possible new approaches to enhance the effectiveness and visibility of input from industry into research priority setting. Seminars at stations are being conducted to inform senior scientists of the scope and possibilities of branch relations with industry and to identify specific technology for potential co-development and transfer.

CROP PRODUCTION

Input to policy, planning, and program development

The directorate represented the branch on the departmental market-oriented, commodity-based development strategy teams, which developed commodity strategies for the Grains and Oilseeds, Horticulture, and Special Crops sectors. These strategies identified actions and recommendations to address priority constraints and opportunities to increase access to markets.

National Advisory Committees on Grains and Oilseeds, Horticulture, and Special Crops were established within the Research Branch to assist in delivering effective and efficient research programs and to provide appropriate regional inputs to program priorities, particularly in relation to departmental commodity strategy developments.

Directorate personnel organized and/or participated in workshops on quackgrass and potato pests as well as a review of the berry crops research program in the Atlantic Region.

Appropriate research goals for the crops research programs were developed and integrated into the branch head's work plan. Significant research accomplishments and deviations from the work plan were documented on a quarterly basis.

Interbranch and interdepartmental activities

The directorate represented the branch on the National Research Council Committee on Industrial Research Assistance (IRA), which evaluates and recommends on proposals for the IRA program funding and on the departmental New Crop Development Fund Advisory Board, which allocates funds to projects having the objective of evaluating the potential of new crops for Canadian production.

The directorate represented the branch on the Steering Committee, which reviewed and recommended changes to the seed potato management program in the Food Production and Inspection Branch.

Extramural activities

Relations with the seed industry were maintained through directorate membership in the Canadian Seed Growers' Association and in the SeCan Association as well as by frequent interactions with the Canadian Seed Trade Association.

Directorate personnel organized and held consultations on research needs and priorities with representatives of the floriculture and nursery industries, and participated with other branches of Agriculture Canada in general discussions of industry needs and government services.

Directorate personnel cooperated with the Canadian Horticultural Council in the publication of a report on horticultural research carried out at all federal and provincial government establishments and at universities in Canada.

The directorate represented the branch on committees respecting asparagus and potato chips research programs supported by funds from industry and remission of duties on products imported into Canada from the United States.

Consultation, advice, and leadership were provided in the crops area at the national level through representation on the Canada Committee on Crop Production Services as well as on the Expert Committees on Horticulture, Weeds, Plant Gene Resources, and Grains and Oilseeds.

ANIMAL PRODUCTION

Input to policy, planning, and program development

An economic analysis of the returns of the animal research program productivity between 1968 and 1985 was prepared under contract for Program Evaluation Division. The study concluded that animal productivity research has generated and likely will continue to generate substantial net benefits to the Canadian economy.

Poultry and sheep programs were reviewed by external committees made up of representatives from universities, industry, and the provincial governments. These established the base for national coordination of the programs.

Interbranch and interdepartmental activities

PCD assisted Commodity Coordination Directorate in the preparation of the commodity plans for the department. Representation was provided on the Canadian Council of Animal Care.

External activities

PCD has played a major role in ensuring continued cooperation and consultation between the Research Branch and the Dairy Farmers of Canada, the Canadian Pork Council, the Canadian Cattlemen's Association, and the Canadian Sheep Council.

NATURAL RESOURCES

Input to policy, planning, and program development

Contributions were made to a report to Agriculture Ministers on Soil and Water Conservation and Development under a charge from the First Ministers' Conference. This involved consultations in all provinces and resulted in major recommendations to achieve long-term sustainment of Canadian agriculture. Subsequently, preparation of a Soil and Water Strategy was begun as part of the National Agricultural Strategy initiated by First Ministers. A related activity was a keynote presentation to a national conference "In search of soil conservation strategies for Canada" in Saskatoon, sponsored by the Agriculture Institute of Canada and other agencies.

Information was gathered for program planning and development by meeting with over half the scientists involved in natural resources research and inventory at establishments from coast to coast. Research needs were analyzed in relation to the evolving strategies and provincial priorities and justification was presented for reallocation of resources to high priority land resources research, evaluation, and surveys.

Natural resources staff were involved in plans to structure departmental research programs in line with the recent Cabinet decision on Technology Centre policy.

Interbranch and interdepartmental activities

Research Branch and the department were represented on various interjurisdictional forums, including the Interdepartmental Committee on Land (ICL) and the Interdepartmental Committee on Water (ICW). Participation on the ICW Mandate Review Committee assisted in restructuring that committee to make it more effective in coordinating federal water programs. Participation on the ICW Water Quality Subcommittee consisted of coordinating input of Agriculture Canada expertise in the preparation of new Water Quality Guidelines for Canada.

Agricultural interests were also represented on the Nonpoint Source Subcommittee of the Great Lakes Water Quality Board, which is primarily concerned about toxic substances and phosphorus from farmland.

A position was prepared on branch soil survey operations in response to the Ministerial Task Force on Major Surveys. This resulted in proper consideration of Agriculture Canada interests in three Memoranda to Cabinet dealing with new policy initiatives for surveys in the federal government.

The issues of impact of Long Range Transport of Air Pollutants were evaluated through participation on the interdepartmental committee on this subject. Specialists collaborated with the Atmospheric Environment Service on studies of climatic change to assess the long-term impact of the "greenhouse effect" on Canadian agriculture. Universities and the international community also participated.

The directorate participated in the development of the Canadian space program and supported the activities of the Interdepartmental Committee on Space.

Responsibilities were also assumed on other interdepartmental committees for coordinating science programs in biotechnolgy and energy. Bilateral meetings were organized with MOSST on the development and implementation of the "Decision framework," which provides new guidelines for the Science and Technology Strategy.

Support to CASCC

In addition to the normal assessment of research needs under CASCC committees and the review of its research recommendations, a secretariat function was provided to the Canada Committee on Land Resource Services. This included publication, with the financial support of CARC, of a report entitled *Land: A fragile resource: New goals for agricultural land research.* This report has been in high demand and provides a basis for setting research priorities.

Extramural activities

A presentation of the national perspective was made to a strategic planning conference for soil and water programs in the Ontario Ministry of Agriculture and Food.

Contributions were also made to the development of the departmental response to an Order in Council that initiated new environmental impact assessment procedures within the federal government.

Discussions were held in England and Germany on research coordination, priority setting, and privatization of soil surveys and research.

ANIMAL AND CROP PROTECTION

Input to policy, planning, and program development

As a follow-up to the work planning meeting on pest management held in Mont Sainte-Marie in 1985, a Workshop on Biological Control was held in Winnipeg on 9–10 October 1986. Thirty-six participants from federal and provincial departments, universities, and the private sector were present. More than 40 recommendations were made concerning enhancement of the use of biological control methods in integrated pest management (IPM) systems; factors affecting the feasibility of the biological control approach; a National Advisory Committee on Biological Control; funding for Commonwealth Institute of Biological Control (CIBC) projects and other sources of imported biological control material; the need to amend or enhance legislation; major constraints affecting augmentation and inundation; research on genetic resistance; research on the use of microorganisms for biological control; means to accelerate the development of biopesticides.

A Workshop on Integrated Pest Management (IPM) in apple orchards was also held at Saint-Jean-sur-Richelieu Research Station, 25–26 November 1986. Nineteen participants from Agriculture Canada, provincial departments, and the private sector from Nova Scotia, Quebec, Ontario, and British Columbia were present. The need for better communication, coordination, and planning at the regional and national levels was stressed by the participants. Increased technical support, increased funds for travel, and the need to maintain a core of expertise in key disciplines were identified as high priorities.

Interbranch and interdepartmental activities

The Research Branch was represented by the Program Coordination Directorate (PCD) on the Federal–Provincial Task Force on Research and Technology Transfer, contributing to the report to the Ministers Responsible for Agriculture in Canada, and the development of a National Agriculture Strategy.

The directorate provided input into the Audit and Evaluation Branch's plant health and input assurance evaluation study and into the evaluation of the future role of the Federal Interdepartmental Committee on Pesticides.

Support to CASCC

PCD provided leadership for the Expert Committee on Insect Pests of Animals, which reviewed and recommended future research needs and priorities for biting fly research in Canada.

Extramural activities

In its role of providing liaison for Commonwealth Agricultural Bureaux (CAB) International, the directorate provided leadership in reviewing Canada's participation in the organization and cooperation with the Commonwealth Institute of Biological Control.

In cooperation with the Canadian Association of Professional Apiculturists (CAPA) and the Canadian Honey Council (CHC), an Apiculture Research Workshop was held in Charlottetown, 17–18 November 1986 to review priorities for research and formulate action plans. Recommendations were made concerning the need for research on bee diseases and pests, bee supply, colony management, stock improvement, pollination–pesticide interactions, and bee botany.

FOOD RESEARCH

Input to policy, planning, and program development

A work planning meeting on meat quality, jointly sponsored by Food Production and Inspection Branch and Research Branch, was held in Winnipeg in October. About half of the 50 participants represented the private sector. Recommendations that will guide the direction of research in meat quality were developed and prioritized.

An evaluation of the food research program was conducted by the Audit and Evaluation Branch. The research coordinator served on the Program Evaluation Review Group and worked closely with the evaluation team, serving as a contact with the research establishments.

The PCD personnel provided leadership in the development of a human resource plan for the Research Branch.

Support to CASCC

In addition to the normal consultations under CASCC and its research recommendations, the secretarial function was provided by Program Coordination Directorate to the Canada Committee on Food.

Interbranch and interdepartmental activities

Program Coordination Directorate assisted on the departmental reviews of nonmission activities by serving on the Task Force on Personnel and Training.

Extramural activities

An invited review paper on food texture was presented at the University of Nottingham's Easter School Series in Agricultural Science.

INTERNATIONAL RESEARCH AND DEVELOPMENT

Research Branch scientists maintain a vigorous program of international science and technology exchanges with agricultural researchers around the world. The branch also supports departmental objectives in the development, maintenance, and expansion of export markets by providing technical expertise to other branches and agencies. In addition, the branch contributes to technological advancement in less-developed countries by having its managers and research staff participate in Canadian development assistance programs and by training foreign scientists in branch establishments.

In 1986, all these activities were coordinated across the branch by the international research and development component of the Program Coordination Directorate. Bilateral and multilateral relations were coordinated with some 55 countries and international agencies in order to enhance our domestic research capability and to ensure that Canadian government policies on agricultural science and technology are supported and encouraged internationally.

Highlights of international coordination during the year included a new round of formal consultations with France and Japan for collaborative research projects under agreements between the Government of Canada and the governments of these countries, for exchange of science and technology. In total, branch activities under some 15 formal agreements or memoranda of understanding with other countries were monitored and coordinated in the directorate.

The branch hosted the 1986 Tetrapartite Meeting of national agricultural research directors from the United Kingdom, United States, France, and Canada. The meeting in Ottawa coincided with the branch centennial celebrations.

The directorate also organized and hosted, on behalf of Canada, the mid-term meeting of the Consultative Group on International Agricultural Research (CGIAR). Some 40 donor countries and agencies of the CGIAR were represented at the meeting in the Government Conference Centre in Ottawa. The program began with a special 1-day Agriculture Canada presentation at the Central Experimental Farm on Canadian scientific and technical contributions to international agricultural research.

Branch involvement in official development assistance programs continue to be coordinated by the directorate. In 1986, the branch was responsible for the management of 10 official development projects in six countries, funded by the Canadian International Development Agency (CIDA). Branch scientists also provided expertise for a wide range of other foreign activities to CIDA and the International Development Research Centre (IDRC).

Branch specialists continued throughout the year to tackle various technical issues related to the international marketing of Canadian agricultural products, and to lend expert support to promotional activities, such as technical seminars and trade expositions, in priority countries with potential for expanded markets for Canadian agriculture.

All of these activities were coordinated through the Program Coordination Directorate.

Research Program Service
Ottawa, Ontario

PROFESSIONAL STAFF

Administration

Y. Bélanger, B.Sc.	Director
D.W. Friel[1]	Administration and awards
A. Severn[2]	Administration and awards, acting
W.L. Fettes	Branch liaison

Art and Design

C.N. Halchuk	Head of Section

Audiovisual

W.G. Wilson	Head of Section

Scientific Editing

J.A. Perrin,[3] B.Sc.	Head of Section
S.M. Rudnitski, B.Sc.	Acting Head of Section
S.V. Balchin	Editing
N. Rousseau, B.A., M.A.	Editing
D.R. Sabourin, B.A.	Editing
F. Smith, B.A.	Editing

Scientific Information Retrieval

J. Taky, B.A., B.Sc., M.P.A.	Head of Section
P. Beauchamp, B.Sc., M.Sc.	Herbicides
J.R. Kennett, B.Sc.	Inventory and systems
H.S. Krehm,[4] B.A., M.A., Ph.D.	Fungicides and insecticides
C.D. Laing, B.Sc., M.Sc.	Inventory and systems
E.K. McMillan, B.Sc.	Inventory and systems
R. McNeil, B.Sc.	Inventory and systems

Departures

D.M. Archibald, B.A. Retired 29 December 1986	Acting Head of Section
J.S. Kelleher, B.Sc., M.Sc., Ph.D. Transferred to Biosystematics Research Centre	Biocontrol
R. Makowski, B.Sc., M.Sc. Educational leave, September 1983	Scientific information

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[1] Seconded to Central Experimental Farm Administration.

[2] Seconded from Central Experimental Farm Administration.

[3] Seconded to Branch Executive.

[4] Seconded to Food Production and Inspection Branch.

INTRODUCTION

Research Program Service supports research and development in the branch by maintaining computerized scientific and technical information systems, providing publications services, and administering branch awards and international scientific exchange programs. In 1986 the former Graphics Section was divided into two new sections: Art and Design, and Audiovisual. The service is now made up of five sections: Administration, which contains the awards, branch liaison, and word processing units; Art and Design; Audiovisual, which provides photographic, audiovisual, and computer graphics services; Scientific Editing, which comprises English and French editors; and Scientific Information Retrieval, which contains the inventory and systems unit and the pesticides unit.

The Administration Section continued to administer the program for operating grants and visiting fellowships, and to coordinate international missions. Research Branch staff was informed of news, happenings, and accomplishments through nine issues of *Tableau*.

Art and Design, Audiovisual, and Scientific Editing sections combined their efforts to maintain and improve the high quality of production of publications and support material necessary for the transfer of knowledge and technology to the scientific community and the agri-food sector. Many special projects were completed to mark the centennial of the Research Branch.

The Scientific Information Retrieval Section has put into service a new component to the Pesticide Research Information System, namely, the Paralease (Insect Release Data). Responsibility for the biocontrol unit was transferred to the Biosystematics Research Centre.

Further information can be obtained from the Director, Research Program Service, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

Yves Belanger
Director

AWARDS AND BRANCH LIAISON

Research Program Service continued to administer the operating grants, visiting fellowships, and scientific exchange programs during 1986. Operating grants are awarded to individual researchers at Canadian universities as contributions toward the costs of proposed research projects that will be of value to the agricultural industry. The selection committee is made up of three representatives from Agriculture Canada, seven from faculties of agriculture and veterinary science, and one from the Canadian Agricultural Research Council. In 1986, the committee received 239 applications.

The visiting fellowship program gives promising young scientists, from all over the world, the opportunity to work with distinguished researchers in their respective fields before embarking on careers in scientific research. The program is administered by the Natural Sciences and Engineering Research Council on behalf of Canadian government departments and agencies. Research Program Service acts as liaison between the council and Agriculture Canada. In 1986, there were 281 applications for fellowships in this department.

The branch liaison unit arranged for 58 scientists to visit branch establishments during the past year. Three missions came from France, two from New Zealand, two from the United States, and one each from Belgium, the Federal Republic of Germany, Japan, Pakistan, the People's Republic of China, Syria, and the United Kingdom. The unit also made arrangements for eight scientists to visit France and for two to visit the USSR.

ART AND DESIGN

Owing to the diversification of services provided, the former Graphics Section was split into two separate but closely coordinated sections: Art and Design, and Audiovisual. Together the two sections handled a total of 2761 jobs, representing an increase of 11% over 1985 and generating the production of 63 208 pieces of work.

The Art and Design Section provided a wide variety of services in art production and illustrations to the branch and other agencies within the department. Many special projects were completed for the Research Branch Centennial, including *One Hundred Harvests/Cent Moissons*, the history of the Research Branch; the Centennial Issue of *Tableau*; eight history publications and 18 history folders on our research stations; the Plant Research Centre display; and exhibits for the Centennial Chrysanthemum Show. In addition, the section produced many signs for the Central Experimental Farm and matted and framed many paintings and historical photographs.

AUDIOVISUAL SECTION

Increased production in the Audiovisual Section (formerly the photo unit) was highlighted by an increase of 99.1% in micro/macro photography, 43.9% in line and continuous contact prints, 40.8% in color enlargements, and 33.1% in color film processing. Field photography increased by 25.7%, black-and-white film processing by 18.7%, black-and-white printing by 11.8%, and the production of Diazochrome and black-and-white slides by 10.2%. The only decrease, 8.1% in color slides of color copy, was due to lower demand for this type of slide and greater use of computer-graphic color slides.

SCIENTIFIC EDITING

During the year, 21 departmental (five priced) and 70 Research Branch publications were issued.

We marked Centennial year by producing eight full-length books in the Historical Series and 18 historical folders and station guides for the branch. Featured was the release on 2 June 1986 of *One Hundred Harvests* and *Cent Moissons*, the English and French versions of the detailed history of the Research Branch. Special centennial issues of *Tableau* and *Progress in Research/État de la recherche* were also published.

Some other noteworthy publications released in 1986 were:

- *Champignons nocifs et vénéneux du Canada*, the 420-page French-language version of *Poisonous Mushrooms of Canada* published the previous year (priced)
- *Land – A Fragile Resource/La terre – une ressource fragile*, a full-color 50-page promotional brochure outlining new goals for agricultural land research
- *Insect Pests of Flour Mills, Grain Elevators, and Feed Mills and their Control* and *Insectes nuisibles des minoteries, des silos-élévateurs, des usines à provendes et méthodes de désinfestation*, 300-page comprehensive references in hard-cover editions (priced)
- *Part 13. The Carrion Beetles of Canada and Alaska*, a 120-page book in *The Insects and Arachnids of Canada* series (priced)
- *Part 14. The Grasshoppers, Crickets, and Related Insects of Canada and Adjacent Regions*, a 900-page volume in *The Insects and Arachnids of Canada* series (priced)
- *Research Branch Report*, the 400-page annual record of research done throughout the branch.

Some of the free departmental publications, published in both languages unless otherwise indicated, included:

- *Beef Production from the Dairy Herd*
- *Growing and Managing Alfalfa in Canada* (English only)
- *Leafhoppers of Ornamental and Fruit Trees in Canada*
- *Good Energy Management in Farm Livestock Buildings*
- *Choice and Use of Chemical Sanitizers in the Food Industry*.

In addition, two soil surveys, the *Pesticide Research Report*, 14 Expert Committees reports, nine regularly scheduled issues of *Tableau*, and four issues of *Pesticide Information/Information pesticides* were produced.

SCIENTIFIC INFORMATION RETRIEVAL

The Inventory of Canadian Agri-Food Research (ICAR) and the Research Branch project system were updated in the course of the year. Access to both these computerized databases continues to be provided across Canada to the whole research community and to Research Branch personnel. The 1986 version of ICAR provides information on over 4300 agri-food research projects being carried out in Canada. The distribution of research effort by commodity and discipline was tabulated in the ICAR summary tables, which were widely distributed. Recipients included the national focal points for exchange of scientific information among nations belonging to the Organization for Economic Cooperation and Development. Visiting delegations were welcomed from Japan, Great Britain, and New Zealand.

An eighth component, on the status of submissions to the minor use of pesticides program, was added to the Pesticide Research Information System (PRIS). The number of subscribers to this computerized information system has increased in Canada, particularly in the private sector. Discussions with the National Research Council concerning networking of this cluster of databases to their CAN/OLE system are progressing well.

The section has continued to administer the minor use of pesticides program and to coordinate the activities of the various agencies concerned. In 1986, 32 submissions to the program were received, mostly from British Columbia and Ontario, and 16 new uses were accepted for registration. This program has improved Canada's production capability on a wide range of crops and brought about substantial gains for producers. Regional coordination of the program improved substantially, and the *Minor Use Handbook* was distributed as a special issue of the newsletter *Pesticide Information*, which continued to be published quarterly.

Responsibility for the biocontrol unit was transferred to the Biosystematics Research Centre.

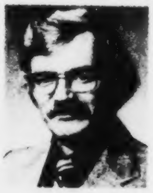
In addition to their regular activities, section staff supported the Expert Committee on Pesticide Use in Agriculture, the Expert Committee on Weeds, the Canada Committee on Crop Production, the Canada Committee on Food, the Canadian Horticultural Council, and the Canadian Standards Association. They also participated in the evaluation of an electronic database management system and a computer-assisted drafting/publishing system.

Central Experimental Farm Directorate

Direction de la Ferme expérimentale centrale

J.J. Cartier

E. Larmond



D.G. Proctor

Acting Director General *Directeur général, intérimaire*	J.J. Cartier, B.A., B.Sc., Ph.D.
Program Specialist *Spécialiste en programmes*	Elizabeth Larmond, B.Sc.
Chief, Administration *Chef de l'administration*	D.G. Proctor

PREFACE

The Central Experimental Farm Directorate, located at the Central Experimental Farm in Ottawa, consists of the Animal Research Centre (ARC), Biosystematics Research Centre (BRC), Engineering and Statistical Research Centre (ESRC), Land Resource Research Centre (LRRC), and Plant Research Centre (PRC). In 1986, the programs were conducted by a complement of 930 person years with a budget of $51 million. All the centres combine active research on national programs with service to regional stations or to the public in specialized areas of their research. Significant research accomplishments are highlighted in the reports of the individual centres.

The Animal Research Centre conducts research in nutrition, physiology, management, breeding, product quality, disease resistance, and genetics in beef and dairy cattle, swine, poultry, and sheep; animal waste management; and food safety and nutrition. The centre strives mainly toward improving the productive efficiency of intensively housed and managed livestock and poultry. Increased emphasis is placed on the introduction of the most up-to-date biotechnology methods to animal research. Mycotoxin research is providing sound guidelines on contamination tolerance in feeds.

The Biosystematics Research Centre provides Agriculture Canada and other departments, agencies, and their clients with a unique centre of systematic expertise for dealing with economic and social problems relating to insects, mites, spiders, plant parasitic nematodes, weeds, crop plants, native plants, plant parasitic and biodegrading fungi, and nonmedical bacteria. As the only Canadian organization with comprehensive collections, systematic research, and identification expertise, BRC continues to provide all systematic services to support production and resource protection for two major Canadian industries, agriculture and forestry. Research activities have been progressively realigned in response to demands on areas such as integrated pest management, environmental protection, and biotechnology.

The Engineering and Statistical Research Centre provides the Research Branch with a centre of expertise where engineers and statisticians carry out research and analyses to improve agricultural and food production and inspection systems and to support research by other disciplines.

The activities of the Land Resource Research Centre include research, development, and services related to Canada's land resources. The centre provides leadership and is responsible for the following national programs: soil inventory, Canada soil inventory system, soil taxonomy and interpretation, soil degradation, land evaluation, crop information system, and agroclimatic resources.

The Plant Research Centre was established on 1 April 1986, by amalgamating the Ottawa Research Station and the Chemistry and Biology Research Institute. The mandate includes the development of effective technologies for crop improvement and plant health through innovative and multidisciplinary research with emphasis on biotechnology as well as the development and release of superior cultivars in selected crop species of regional and national interest. PRC maintains strong breeding programs on corn, soybeans, oats, wheat, barley, alfalfa, and forage grasses. It also has substantial programs in biotechnology with emphasis on the development and exploitation of new technologies in tissue culture, molecular biology, and cell genetics. The objectives of these programs are to provide new and improved tools for the development of new cultivars and germ plasm with improved resistance to biotic and abiotic stresses, as well as more effective *Rhizobium* strains, to reduce the cost of crop production, and to recommend safer and more effective methods of crop protection. PRC also houses the central office for the Plant Gene Resources of Canada, which is responsible for the preservation and exchange of genetics resources and is also responsible for the management of the entire Central Experimental Farm including the campus, the arboretum, and the ornamental gardens.

Further information about our programs may be obtained by writing to the research establishments concerned or by addressing inquiries to the Central Experimental Farm Directorate, Research Branch, Agriculture Canada, Room 2101, K.W. Neatby Building, Ottawa, Ontario, K1A 0C6; Tel. (613) 995-7084.

J.J. Cartier
Director General

PRÉFACE

La Direction de la Ferme expérimentale centrale, située à la Ferme expérimentale centrale à Ottawa, comprend le Centre de recherches zootechniques (CRZ), le Centre de recherches biosystématiques (CRB), le Centre de recherches techniques et de statistiques (CRTS), le Centre de recherches sur les terres (CRT) et, enfin, le Centre de recherches phytotechniques (CRP). En 1986, la Direction a géré des effectifs de 930 années-personnes et un budget de 51 millions de dollars. Tous les centres allient la recherche active dans le cadre des programmes nationaux et la prestation de services spécialisés aux stations régionales ou au public. Chaque centre souligne ses réalisations d'importance dans son rapport annuel.

Au Centre de recherches zootechniques, les chercheurs axent leurs travaux sur la nutrition, la physiologie, les pratiques d'élevage, la reproduction, la qualité du produit, la résistance aux maladies et la génétique appliqués aux bovins de boucherie, aux bovins laitiers, aux porcs, à la volaille et aux ovins; les recherches portent également sur le traitement des déchets animaux, sur l'innocuité des aliments et sur la nutrition. Le Centre vise surtout à accroître la productivité des bestiaux et de la volaille en élevage intensif. On met surtout l'accent sur l'application des méthodes biotechnologiques les plus perfectionnées à la recherche animale. Les travaux sur les mycotoxines permettent d'établir des lignes directrices saines sur les seuils de tolérances concernant la contamination des aliments pour bestiaux.

Le Centre de recherches biosystématiques offre à Agriculture Canada et à d'autres ministères et organismes, ainsi qu'à leurs clients un centre unique d'expertise où l'on résoud les problèmes socio-économiques causés par les insectes, les acariens, les araignées, les nématodes parasites des végétaux, les mauvaises herbes, les plantes cultivées, les plantes indigènes, les champignons parasites des plantes et biodégradants et les bactéries dépourvues d'intérêt médical. Grâce à ces collections complètes, à son service d'identification et à sa capacité de recherches systématiques, le CRB peut dispenser aux deux grands secteurs canadiens que sont l'agriculture et les forêts, tous les services nécessaires à la production et à la protection des ressources. Face à la demande, il a progressivement réorienté ses travaux dans les domaines de la lutte anti-parasitaire intégrée, de la protection de l'environnement et de la biotechnologie.

Pour sa part, le CRTS dispense à la Direction générale des services d'experts-conseils; ses ingénieurs et ses statisticiens mènent des recherches et des analyses pour améliorer la production agro-alimentaire et le système d'inspection et pour appuyer les travaux dans d'autres domaines.

Le Centre de recherches sur les terres (CRT) s'occupe de recherche et de développement et offre des services liés aux ressources en terres du Canada. Il joue un rôle-clé et assume la mise en oeuvre des programmes nationaux dans les domaines de la prospection pédologique; du système canadien d'inventaire des sols; de la classification, de l'analyse et de la dégradation des sols; de l'évaluation des terres; du système d'information sur les cultures; des ressources agro-climatiques.

Le Centre de recherches phytotechniques a ouvert ses portes le 1er avril 1986 à la suite de la fusion de la Station de recherches d'Ottawa et de l'Institut de recherches chimiques et biologiques. Son mandat consiste à mettre au point des techniques efficaces pour améliorer les cultures et protéger les végétaux. Pour ce faire, les chercheurs mènent des recherches innovatrices et pluridisciplinaires axées sur la biotechnologie, ainsi que sur la création et la diffusion de cultivars supérieurs pour des espèces végétales d'intérêt régional et national. Le Centre mène des travaux intensifs de sélection pour le maïs, le soja, l'avoine, le blé, l'orge, la luzerne et les graminées fourragères. Les importants travaux en biotechnologie portent surtout sur la mise au point et l'application de nouvelles techniques dans les domaines de la culture de tissus, de la biologie moléculaire et de la génétique cellulaire. Ces programmes visent à fournir des outils nouveaux et améliorés nécessaires à la création de nouvelles variétés, du matériel génétique ayant une résistance accrue au stress de nature biologique ou non, ainsi que des souches plus efficaces de *Rhizobium*. Ces progrès réduiraient les coûts de production. Par ailleurs, le Centre pourrait recommander des méthodes plus sûres et plus efficaces de protection des cultures. L'établissement loge également l'administration centrale du Bureau des ressources phytogénétiques du Canada qui est responsable de la conservation et de l'échange du matériel génétique, ainsi que de l'entière gestion de la Ferme expérimentale centrale, notamment le campus, l'arboretum et les jardins de plantes ornementales.

Pour obtenir de plus amples renseignements sur nos programmes, il faut écrire aux établissements de recherches concernés ou adresser les demandes à la Direction de la Ferme expérimentale centrale, Agriculture Canada, pièce 2101, édifice K.W. Neatby, Ottawa (Ontario), K1A 0C6. On peut également téléphoner au (613) 995-7084.

J.J. Cartier

Directeur général

Animal Research Centre, Ottawa Ontario

PROFESSIONAL STAFF

Administration

J.I. Elliot,[1] B.S.A., M.Sc., Ph.D.	Acting Director
J.S. Gavora,[2] Ing., C.Sc.	Acting Deputy Director
D.A. Leger, B.Sc.	Assistant to the Director
D.A. Schmid, B.A.	Chief, Administration and resources
L.M.B. Babin, B.A.	Administrative Officer; Personnel
J.G.R. Boisclair,[3]	Administrative Officer; Finance

Scientific Support

K.G. Hilson,[4] B.Sc., M.Sc.	Project Manager; Computer services
D.L. Brewin,[4]	Programmer–Analyst
D. Campbell,[4]	Programmer–Analyst
B.J. McKelvey	Programmer–Analyst
H.M. Mucha,[4]	Programmer–Analyst
T.D. Osterhout	Programmer
K.E. Hartin, D.V.M.	Veterinarian
J.P. Miska,[5] B.A., B.L.S.	Library services

Biotechnology

J.S. Gavora, Ing., C.Sc.	Program Chairperson; Disease resistance genetics
D.E. Bernon, B.Sc.(Agr.), M.Sc., Ph.D.	Cellular, molecular, and quantitative genetics
A.J. Hackett, D.V.M., M.Sc., Ph.D.	Embryo transfer, female reproductive physiology
G.J. Marcus, B.A., Ph.D.	Maternal–embryonic physiological interactions
J. Nagai, B.Sc., D.Agr.	Embryo manipulation, quantitative genetics
M.P. Sabour, B.Sc., Ph.D.	Molecular and cellular genetics
R.M. Teather, B.Sc., Ph.D.	Genetic manipulation of rumen bacteria

Animal Waste Utilization

N.K. Patni, B.Ch.E., M.Sc., Ph.D.	Program Chairperson; Livestock waste utilization, farm pollution abatement

Dairy and Beef Cattle Nutrition

M. Ivan, Ing., M.Sc., Ph.D.	Program Chairperson; Nutrition and metabolism of trace minerals
A.S. Atwal, B.Sc., M.Sc., Ph.D.	Forage evaluation and nutrition
J.D. Erfle, B.S.A., M.Sc., Ph.D.	Rumen metabolism and nutrition
M. Hidiroglou, D.V.M., Dip. Nutr.	Vitamin and trace mineral nutrition
K.J. Jenkins, B.S.A., M.Sc., Ph.D.	Calf nutrition

J.R. Lessard,[6] B.A., B.S.A., M.S., Ph.D.	Forage conservation and nutrition
S. Mahadevan, B.Sc., M.Sc., Ph.D.	Rumen metabolism and nutrition
F.D. Sauer, D.V.M., M.S., Ph.D.	Rumen metabolism and nutrition
D.M. Veira, B.Sc., M.Sc., Ph.D.	Ruminant nutrition

Dairy Cattle Breeding and Production

A.J. Lee, B.Sc.(Agr.), Ph.D.	Program Chairperson; Dairy cattle breeding and production – statistical methodology and breeding strategies
T.R. Batra, B.V.Sc., M.V.Sc., M.Sc., Ph.D.	Dairy cattle breeding – field data analyses, disease resistance
C.Y. Lin, B.S., M.S., Ph.D.	Dairy cattle breeding – multi-trait mixed model sire and cow evaluation methods; computer modelling
A.J. McAllister, B.S., M.S., Ph.D.	Dairy cattle breeding and production – selection for lifetime performance and use of crossbreeding

Swine Production

D.W. Friend, B.Sc., M.Sc., Ph.D.	Program Chairperson; Sow and piglet production; mycotoxins
A. Fortin, B.Sc.(Agr.), Ph.D.	Carcass composition, quality – swine, poultry, sheep, cattle
D.G. Fraser, B.A., Ph.D.	Animal behavior – swine, sheep, cattle

Poultry Breeding

A.A. Grunder, B.S.A., M.Sc., Ph.D.	Program Chairperson; Eggshell quality genetics, broiler breeding, goose breeding and management
J.R. Chambers, B.Sc., M.Sc., Ph.D.	Broiler breeding and management
R.W. Fairfull, B.Sc., M.Sc., Ph.D.	Egg stock breeding and management
C.P.W. Tsang, B.Sc., M.Sc., Ph.D.	Physiology – eggshell quality and egg production

Poultry Nutrition

I.R. Sibbald, B.Sc.(Agr.), M.Sc., Ph.D., D.Sc.	Program Chairperson; Avian energetics and feedingstuff evaluation
N.A.G. Cave, B.Sc., M.Sc., Ph.D.	Amino acids and proteins, broiler breeder nutrition and management
R.M.G. Hamilton, B.Sc.(Agr.), M.Sc., Ph.D.	Nutrition and physiology – eggshell quality, mycotoxins

Sheep Production

L. Ainsworth, B.Sc., M.Sc., Ph.D.	Program Chairperson; Female reproductive physiology
P.S. Fiser, B.Sc., M.Sc., Ph.D.	Cryopreservation, male reproductive physiology
D.P. Heaney, B.S., M.S., Ph.D.	Nutrition and intensive management
G.A. Langford, B.Sc., M.Sc., Ph.D.	Male reproductive physiology
J.N.B. Shrestha,[7] B.V.Sc.A.H., M.S., Ph.D.	Breeding and intensive production – applied quantitative genetics

Animal Feed Safety and Nutrition

H.L. Trenholm, B.Sc., Ph.D.	Program Chairperson; Mycotoxins, toxicology
M.H. Akhtar, B.Sc., M.Sc., Ph.D.	Pesticide metabolism and residues
L.M. Coté,[8] B.Sc., M.Sc., Ph.D.	Biochemical toxicology, mycotoxins
E.R. Farnworth, B.Sc., M.Sc., Ph.D.	Lipid nutrition and metabolism
J.K.G. Kramer, B.Sc., M.Sc., Ph.D.	Lipid chemistry and biochemistry
D.B. Prelusky, B.Sc.(Pharm.), Ph.D.	Mycotoxin metabolism, toxicology

Departure

R.S. Gowe,[9] B.S.A., M.S., Ph.D., F.P.S.A. Retired 9 October 1986	Director

HONORARY RESEARCH ASSOCIATE

R.S. Gowe, B.S.A., M.S., Ph.D., F.P.S.A.	Egg stock breeding and management

VISITING SCIENTISTS

M.L. Biehl, D.V.M. Department of Veterinary and Biological Sciences, University of Illinois, Urbana, Ill.	Mycotoxin metabolism
W.B. Buck, B.S., D.V.M., M.S. National Animal Poison Control Center, University of Illinois, Urbana, Ill.	Mycotoxins and veterinary toxicology
E. Charmley, B.Sc., Ph.D. University of Reading, Reading, England	Mineral nutrition and forage evaluation
C.W. Forsberg, B.S.A., M.Sc., Ph.D. Department of Microbiology, University of Guelph, Guelph, Ont.	Transfer of DNA in rumen bacteria
S. Gange, B.Sc. Centre de recherche, Hôpital Hôtel-Dieu, Quebec City, Que.	DNA manipulation
L.C.P. Machado, M.Sc. Department of Animal Science, Federal University of Santa Catarina, Florianopolis, Brazil	Livestock behavior

Natural Sciences and Engineering Research Council (Can.) postdoctorate fellows

C.L. Boogaard, B.A., M.Sc., Ph.D., 1986–1987	DNA manipulation and disease resistance
L.L. Charmley, B.Sc., Ph.D., 1985–1987	Copper metabolism
G. Davis, B.Sc., Ph.D., 1986–1987	Embryo manipulation
B.C. Foster, B.Sc., Ph.D., 1984–1986	Toxicology of mycotoxin-contaminated grains

R. Gopinath, B.Sc., M.Sc., Ph.D., 1984–1986	Amino acid metabolism of rumen microorganisms
J.E. Irwin, B.Sc., Ph.D., 1985–1986	Gene cloning in rumen bacteria
J.F. Patience, B.Sc.(Agr.), M.Sc., Ph.D., 1985–1987	Swine nutrition and metabolism; acid-base homeostasis
B. Pawluczuk, B.Sc., M.Sc., Ph.D., 1985–1987	Carcass quality measurement and artificial insemination in geese
K.H. Ponzilius, B.Sc., M.Sc., Ph.D., 1984–1986	Embryo splitting and manipulation
J.P. Rushen, B.Sc., Ph.D., 1985–1987	Behavior of swine and sheep in intensive husbandry systems

Canadian International Development Agency (CIDA) trainees (Canada–Brazil project)

A. Bona, B.Sc., M.Sc. Parana State Agricultural Research Institute (IAPAR), Londrina, Brazil	Dairy cattle nutrition and management
M.S. Dayrell, B.Sc., D.Sc. National Dairy Cattle Research Centre (CNPGL), Coronel Pacheco, Brazil	Ruminant mineral nutrition
C.M. Jaume, Agr. Eng., Ph.D. National Dairy Cattle Research Centre (CNPGL), Coronel Pacheco, Brazil	Dairy cattle reproductive physiology
M.L. Martinez, B.S., M.S., Ph.D. National Dairy Cattle Research Centre (CNPGL), Coronel Pacheco, Brazil	Dairy cattle breeding and selection
D. Perotto, M.Sc. Parana State Agricultural Research Institute (IAPAR), Londrina, Brazil	Dairy cattle breeding and selection
J.K. Tahira, B.Sc., M.Sc. Parana State Agricultural Research Institute (IAPAR), Londrina, Brazil	Dairy cattle reproduction
S.R.M. Vega, B.Sc., M.Sc. Parana State Agricultural Research Institute (IAPAR), Londrina, Brazil	Ruminant mineral nutrition

Canadian University Services Overseas (CUSO) trainee (Canada–Cuba project)

M.P. Pla, Agr. Eng. Poultry Research Institute, Havana, Cuba	Poultry breeding and selection

United Nations Food and Agriculture Organization (FAO) trainee

L.F.T. Albino, M.Sc. National Centre for Swine and Poultry Research (CNPSA), Concordia, Brazil	Poultry feedingstuff evaluation

Agriculture Canada research contract

J.E. Irwin, B.Sc., Ph.D.	Gene cloning in rumen bacteria

Graduate students

W.B. Peeters-Weem, B.Sc.	Swine behavior
H.V. Petit, Bacc., M.Sc.	Calf nutrition

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[1] Acting Director from 10 October 1986.

[2] Acting Deputy Director from 10 October 1986 to 31 December 1986.

[3] Appointed 3 February 1986.

[4] Seconded from Systems and Consulting Directorate, Corporate Management Branch.

[5] Seconded from Libraries Division, Corporate Management Branch.

[6] Seconded to Headquarters Research Branch since 1 November 1981.

[7] On transfer of work at Department of Animal Science, Cornell University, Ithaca, N.Y., from 1 November 1986 to 31 October 1987.

[8] Returned from education leave at the University of Illinois, Urbana, Ill., 1 April 1986.

[9] Retired 9 October 1986.

INTRODUCTION

The major research aim of the Animal Research Centre (ARC) is to resolve the numerous problems associated with improving the production efficiency of intensively housed and managed livestock and poultry. The centre is the main Canadian location for research on breeding and genetics of dairy cattle, sheep, and poultry. It also has major programs in biotechnology and in the nutrition of dairy and beef cattle, swine, poultry, and sheep. In addition, studies are under way in the following areas: animal waste utilization and management; reproductive physiology; trace mineral and vitamin requirements; dietary utilization of fats and oils; pesticide metabolism and residues; animal behavior in intensive production systems; carcass evaluation; ruminant digestive physiology; and the effects and metabolism of toxic contaminants in animal feeds. ARC has nine multidisciplinary program teams composed of researchers with a broad range of scientific knowledge. Both applied and basic studies, directly related to the solution of practical problems, are under way.

A significant development in 1986 was the retirement of Robb Gowe as director of ARC. Dr. Gowe joined Agriculture Canada in 1949 and became ARC director in 1965. An internationally recognized poultry geneticist, he successfully combined a vigorous and productive scientific career with the administration of one of the largest, most complex establishments in the Research Branch. A major accomplishment was the development of the ARC research farm. During his 21-year tenure as director, the centre developed into a world-class research location for livestock and poultry production research. As an emeritus scientist he will continue his personal research on multitrait selection in poultry. This work and his strong leadership in the other research areas of the centre will have a lasting effect on Canadian livestock and poultry production.

The effective transfer of research results from the laboratory to the farmer–user is a major ARC priority. Research findings were published in 75 scientific and 68 technical and popular-press articles. A major contribution was the technical bulletin *The T.M.E. system of feed evaluation: Methodology, feed composition data, and bibliography.* The scientific paper describing the original bioassay for true metabolizable energy was recognized as a Citation Classic by the publication *Current Contents.* The number of scientific staff members invited to international symposiums and conferences remains high. Representative was the visit by Humayoun Akhtar to Yugoslavia, to participate in work planning meetings on pesticide residues research by the Food and Agriculture Organization (FAO). Among the over 400 visitors to ARC and the research farm, the centre was especially honored by the Minister of Agriculture from New Zealand, the chairman of the Science Council of Canada, a Chinese agricultural mission, the directors of agricultural research from Syria and Brazil, and numerous Canadian and international producer groups, scientists, and extension workers.

ARC continued extensive participation in cooperative research and development programs in Venezuela, Brazil, and Cuba in the areas of dairy cattle and poultry breeding and dairy cattle production. A major project with Brazil involved the Dairy Research Centre of the Brazilian National Agricultural Research Organization and its counterpart in the State of Parana. Seven researchers from these two establishments spent 3–6 months with ARC dairy and beef nutritionists, physiologists, and geneticists.

Scientists continued to receive national recognition of excellence in research. The Agricultural Institute of Canada (Canadian Society of Animal Science) presented Mike Ivan with the Canada Packers Medal for Excellence in Nutrition and Meat Sciences. He was honored for his studies in ruminant mineral metabolism and is the third ARC recipient in 2 years. For the fourth time in 8 years, ARC researchers received the prestigious Merit Award of the Government of Canada. Kenneth Jenkins and Michel Hidiroglou were jointly recognized for their outstanding research on the use of selenium to correct nutritional muscular dystrophy and other nutritional problems caused by dietary selenium deficiency.

ARC was active with other Central Experimental Farm (CEF) establishments in celebrating the Research Branch centennial. A main component of ARC activities was an information kiosk located adjacent to the CEF ornamental gardens. Recent research success stories were presented using photographs and text. Visitors appeared to enjoy the display.

The animal feed safety and nutrition program was strengthened with the return of Marie Cote from the University of Illinois, where she received her Ph.D. The problem area of feed contaminants will be expanded as Dr. Coté investigates the toxicological effects of substances such as mycotoxins on livestock and poultry. In a continuing evaluation of the direction of research, ARC participated in major Research Branch reviews of programs in poultry and sheep.

This annual review highlights research for 1986. Some findings that are particularly noteworthy include the following: alternative manure application methods did not alter soil chemistry; a new method was developed to protect soybean meal from rumen degradation, which could lead to savings in the cost of protein feeding; the usefulness of fish meal was confirmed as a supplement for beef steers fed grass silage and housed in northern Canada; detailed information was obtained on the complex enzymes responsible for dietary fiber degradation in the ruminant; the effectiveness of various chemical inhibitors of methane synthesis was examined and their role in ruminant feed efficiency demonstrated; research showed the value and high potential of naked oats as a dietary ingredient for growing and finishing pigs and laying hens, findings that will encourage wider acceptance of this feedstuff; the effects of transportation and rest time on swine carcass quality indicated that both factors contribute to the incidence of poor-quality pork; the usefulness of needle teeth was shown in improving the competitive ability of piglets having a low birth weight; for calves, excellent protection against nutritional muscular dystrophy was achieved with increased dietary levels of selenium, although this element did not affect the incidence of retained placentas in breeding cows; the utilization of zinc in sheep was low, and little dietary supplementation was needed; a simple management technique was developed to improve semen collection in geese; it was shown that genetic selection was useful to reduce crippling in broilers; also with broilers, selection for reduced abdominal fat and improved feed efficiency was effective; studies with Leghorns showed the importance of reciprocal effects in selection programs; data analysis showed that cattle management should be improved to reduce levels of early culling; the efficacy of complete dry cow therapy was demonstrated; further results were analyzed for important cow and heifer traits as an outcome of the national dairy project; a new nuclear transplantation technique that makes use of ultraviolet irradiation holds promise for embryo manipulation; the metabolism of deltamethrin was established, and work was started on cyfluthrin and cyhalothrin; the effects of oral ingestion of mycotoxins and their elimination pattern have been established in swine and cattle; a chick embryo test proved useful in determining the toxic potential of certain feedstuffs; significant differences in lamb growth and performance and ewe productivity were established for Canadian sheep breeds; processing procedures for ram semen were further refined to improve spermatozoa survival.

Detailed information on the research accomplishments, methodology, and results can be obtained from the publications listed at the end of this report. Reprints of these publications and copies of this report are available on request from the Animal Research Centre, Headquarters Building, Agriculture Canada, Ottawa, Ont. K1A 0C6; Tel. (613) 993-6002.

J.I. Elliot
Acting Director

BIOTECHNOLOGY

Embryo manipulation

Manipulation of genetically superior embryos is expected to lead to substantially faster genetic improvement compared with conventional breeding. Procedures for manipulation of bovine embryos were investigated, and genetic principles for use of clones were explored for use with a dairy cattle breeding program that integrates the new and conventional breeding procedures.

For embryo collection, 134 young cows were given 36–40 mg of follicle stimulating hormone (FSH) and 50 mg of prostaglandin $F_2\alpha$ (PG). An average of 2.8 embryos were collected in the 83 cows that responded. In 39 older cows ($\geq$3 years old) that responded, the average number of embryos was 3.3. Sixteen cows did not respond. Most embryos were frozen with a standard two-step cryopreservation procedure. A protocol was developed for the 500-cow ARC herd to allow efficient management and use of donor cows also as embryo recipients. Of this population, 100 cows were treated with FSH and PG for embryo collection, twice within 111 days postpartum. One-half of these cows were used as recipients on the day of second embryo collection, and the other 50 cows were inseminated artificially at the estrus subsequent to the second embryo collection. The remaining 400 cows were designated only as recipients. If attempts to transfer embryos into cows designated only as recipients were not successful within 111 days, the cows were artificially inseminated at their next natural estrus.

The expected theoretical accuracy of selecting donor cows based on their own performance and that of their full sib progeny and clones of the progeny was examined. The accuracy, expressed as the correlation between the cow's breeding value and the index combining the performance records, varied depending on the number of records and the trait in question. Assuming that each cow had records from one lactation only, two situations were compared. In the first, progenies from natural ovulation were tested; in the second, 9 clones were produced from each of 18 superovulated embryos. For a trait of low heritability (0.10), the production and testing of clones would markedly improve the accuracy of selection. For traits of moderate heritability (0.40), superovulation and cloning are expected to be less effective in increasing selection accuracy. Under the assumption of three lactation records for each cow, the expected accuracy of selection was high, and cloning did not provide a substantial increase in the precision with which donor cows would be selected for genetic improvement of the herd.

Mouse embryos are being used to develop procedures for cloning through nuclear transplantation. Such cloning requires the removal or inactivation of the pronucleus before a nucleus from a more advanced embryo is transferred into the ovum. A procedure was developed that may be more efficient than microsurgical removal of the pronuclei. Pronuclei of one-cell embryos were inactivated by brief exposure (approximately 20 s) to short-wave ultraviolet irradiation. The irradiated zygotes could no longer undergo mitosis but retained their metabolic integrity. Cell-to-cell chemical fusion, induced by polyethylene glycol, was adopted for introducing a nucleus from an 8–16 cell embryo to allow resumption of development. Attempts to improve the present 50% fusion success are in progress.

Animal molecular genetics

Lymphoid leukosis is a lympho-proliferative disease of chickens, caused by a retrovirus. Although mortality from the disease is generally low, subclinical infections with lymphoid leukosis virus (LLV) have significant negative effects on productivity and cause increased mortality from causes other than lymphoid leukosis. Resistance to LLV infection is simply inherited. It is known that a viral glycoprotein (gp 85) and a genetically controlled cell receptor are involved in viral penetration into host cells. However, the nature of the cellular receptor is not known. Using biochemical and immunological methods, attempts were made in collaboration with the Animal Diseases Research Institute (ADRI) to identify the cellular receptor that causes susceptibility. Rabbit antisera against LLV-susceptible chicken cell membrane antigens were produced. They were applied to chick embryo fibroblast cultures before challenge with Rous sarcoma virus, which causes neoplastic transformation of susceptible cells. The receptors were not blocked by the antisera. Other approaches being tested include the use of cross-linking reagents to immunoprecipitate the LLV-receptor complex.

One LLV is produced by endogenous proviral genes that are a permanent component of chicken genomes. In preliminary research, chickens free of exogenous LLV, which produce the group-specific antigen of LLV from their proviral genes, tended to have a lower annual egg production (12–33 fewer eggs) and a slightly higher mature body weight (80–109 g) than members of the flock that tested negative to the antigen. In two related strains of Leghorns that differed in annual egg production by about 30 eggs, seven endogenous proviral loci were found in the lower producing strain and five in the higher producing strain. Four of these loci were common to both strains, and all birds had at least one proviral gene in their genome.

Recombinant DNA methods are being used to detect DNA polymorphisms that distinguish allelic variations at milk protein loci in cattle genomes. Previous reports showed association of some milk protein genotypes with increased production of milk or milk components. Casein cDNA sequences are now being used to isolate and clone genomic sequences from a bovine genomic library.

Mice that had received the rat growth hormone gene with the metalothionein promoter, as well as their normal controls, were obtained from U.S. scientists for use in studying the behavior of the transferred gene under conventional breeding. As expected, reproductive difficulties were observed in the transgenic mice. The transgenic mice were mated to ARC strains. In a preliminary comparison, an ARC line, which has a normal reproductive success rate and had been selected for high body weight, had substantially greater body size than the transgenic mice.

Genetic manipulation of rumen bacteria

Gene cloning techniques are being applied to rumen bacteria to reduce the costs of ruminant production by increasing the efficiency of feed utilization. A series of synthetic genes, designed to reduce the need for dietary protein in dairy cattle rations, have been cloned in *Escherichia coli* and subcloned into vectors designed to give high levels of gene expression in this organism. The genes are expected to produce bacterial polypeptides composed of amino acids, which are essential for ruminants but are not found at sufficient levels in feed other than concentrates. Methods for introducing these synthetic genes into bacteria are being established, and the design and development of an artificial rumen that will allow these modified bacteria to be tested under controlled laboratory conditions have been completed.

Information about the regulation of gene expression in rumen bacteria, required for effective use of these synthetic genes, is being obtained from the study of the expression of rumen bacteria genes cloned in *E. coli*. The genes being examined are those involved in fiber degradation. Gene banks from fiber-degrading strains of the rumen bacteria *Bacteroides succinogenes*, *Ruminococcus flavefaciens*, and *Butyrivibrio fibrisolvens* have been prepared, and genes specifying β-(1→4)-glucanases (cellulases) and β-(1→4),(1→3)-glucanases, which are involved in the degradation of cereal gums, have been identified and characterized. The regulation of expression in *E. coli* of a β-(1→4),(1→3)-glucanase from *B. succinogenes* has been characterized, an essential step in the effective application of this genetic material. To date, the production of this enzyme in *E. coli* has increased by a factor of about five. In addition to their application in ruminant nutrition, these cloned genes or the enzymes they specify have many potential applications in other areas of animal nutrition and in the industrial utilization of cellulosic wastes.

ANIMAL WASTE UTILIZATION

Loss of total solids (TS) and carbon (C) from tank-stored slurry

Loss of TS from dairy cattle slurry with an initial concentration of 9–10% by weight was limited essentially to the 1-m depth during 5–9 month storage in covered concrete tanks 3 m deep. Aerobic biodegradation starting near the surface and progressing downwards, rather than settling, appeared to be the dominant mechanism for the observed TS and C loss. Most of the initial TS and C were conserved at depths greater than 1 m. A high correlation existed between manure TS determined by weight (oven-drying method) and by volume (centrifugation method).

Effect of manure-cropped systems on soil, crop and water quality

Silage corn yields were not significantly different in 3 successive years when dairy cattle slurry was applied at agronomically recommended rates by alternate application methods and time, namely, fall plowdown, spring disking, and postemergent sidedress injection and broadcasting. Mean concentrations of nitrate-N in shallow groundwater, ranging from 13 to 42 mg/L, were always greater than the drinking water limit of 10 mg/L, even in the untreated control. Soil bulk density was not a sensitive indicator of compaction because of manure tanker traffic. In general, alternate manure application methods did not alter soil chemical composition significantly.

Metolachlor (ME) in drainage water

Analysis has shown that ME concentrations ranged from not detectable to 11 μg/L in tile effluent and in the water in drainage ditches in clay loam soil fields treated with ME at the recommended rates for corn.

DAIRY AND BEEF CATTLE NUTRITION

Protected proteins and amino acids

Currently, formaldehyde is applied to soybean meal (SBM) proteins to protect them from degradation in the rumen and to provide rumen-bypass protein. This process unfortunately destroys amino acids. A new process for protecting SBM was developed in which another protein was chemically treated to make it resistant. The treated protein was applied to SBM to form a thin covering layer. The treated SBM was 70–90% resistant as judged by in vitro enzyme incubation tests and by the nylon bag technique. The amino acid composition of the SBM was not changed.

In ruminants, intact dietary protein becomes unavailable because microorganisms in the rumen degrade the proteins to amino acids, which are further metabolized to NH_4 and CO_2. If amino acid destruction could be controlled, more of the dietary amino acids would become available. When cell extracts from *Megasphaera elsdenii*, *Selenomonas ruminantium*, and *Bytrivibrio fibrisolvens* were incubated singly, most amino acids were not degraded to NH_4. Only threonine, serine, aspartic acid, and glutamic acid were deaminated. When incubated as a mixture, many of the amino acids were readily metabolized, showing that destruction by rumen microbes may be a complicated process involving many amino acids at the same time. Rumen amino acid destruction was more active at pH 6.8 than at higher pH. In vitro destruction of many of the amino acids in the mixture was dependent on the presence of pyridoxal phosphate and nicotinamide adenine nucleotide. Sodium arsenite, hydrazine, monensin, and lasalocid did not effect the destruction of amino acids by the cell-free system. Diphenyl iodonium chloride effectively inhibited the amino acid destruction.

Beef production from grass silage

In the Great Clay Belt of Northern Ontario and Quebec, grass is the main crop, and as silage it is the principal winter feed for beef cattle. In an experiment on protein supplementation of direct-cut grass silage at the Kapuskasing Experimental Farm, ways of maximizing the efficiency of feedlot production were studied. Forty-eight crossbred beef steers were weaned at 6–7 months of age and fed for 196 days on silage alone or supplemented with fish meal (FM) at 100, 225, 350, or 500 g, or on SBM at 600 g. Before weaning, half the steers had been given creep feed at 500 g per day while on pasture. Creep feeding had no effect on growth rate to weaning, but in the feedlot the creep-fed steers gained 100 g per day more than did the controls. The residual effect of creep feeding was not transitory and lasted the whole experiment. The silage was of good quality and when fed alone resulted in gains of 1.06 and 0.92 kg per day after 98 and 196 days, respectively. FM supplementation at 100 g had no effect on growth rate, whereas 225, 350, and 500 g resulted in a linear increase in gain. The highest level of FM increased growth rate by 230 and 210 g per day after 98 and 196 days, respectively, indicating that the effect of FM persisted until animals approached market weight. When fed on an equal-N basis, SBM was as effective as FM during the first half of the experiment but was less effective in the latter stages of fattening. The results indicate that FM improves the efficiency of grass silage-fed steers but that other, cheaper protein sources can also be effective.

Fiber degradation

The ruminant has the unique capacity to derive a major portion of its energy requirements from microbial degradation of dietary fiber. Relatively little is known of the details of the fiber-degrading enzymes. The extracellular cellulases (β-(1→4)-glucanases), hemicellulases (β-(1→4)-xylanases), and other β-glucanases that hydrolyze β-(1→3)-glucans and β-(1→3):β-(1→4) mixed-linkage β-glucans were isolated from rumen bacteria. These enzymes were membrane-bound and were glycoproteins, both properties that complicated their purification. The β-(1→4)-glucanases from two species of rumen bacteria had an extracellular distribution of 37 and 59%, respectively, with carboxymethylcellulose (CMC) and milled filter paper (MFP) for *Bacteroides succinogenes* and 58 and 79% for CMC and MFP, respectively, for *Ruminococcus flavefaciens*. The extracellular distribution of a β-(1→3)-glucanase was 46 and 56%, respectively, for *B. succinogenes* and *R. flavefaciens*. A partly purified β-(1→4)-glucanase from *B. succinogenes* was inhibited 62 and 88% by 100 m*M* glucose and cellobiose, respectively, with CMC as substrate. A similar enzyme preparation from *R. flavefaciens* was inhibited

33 and 71%, respectively. These latter results demonstrate the susceptibility of rumen bacterial β-glucanase to product inhibition.

Methane (CH_4) production

Rumen CH_4 production wastes 10% of gross energy intake. Studies compared the direct inhibition of CH_4 synthesis by rumen methanogens and the indirect inhibition by the ionophore antibiotic monensin (MON), which destroys H_2-producing rumen microbes, which in turn prevent CH_4 synthesis. A rumen simulation system showed that the chemical inhibitor bromoethane sulfonate produced a H_2 increase, stopped CH_4 production, and resulted in significant lowering of redox potential. There was no detectable shift in the production rate of volatile fatty acids (VFA). The addition of MON depressed both H_2 and CH_4 production, did not lower the redox potential, and caused a significant shift in VFA production. Production of acetate and butyrate decreased 78 and 70%, respectively, and propionate and valerate increased. From the thermodynamics of the reactions it was calculated that feeding chemical inhibitors of CH_4 synthesis is unlikely to increase feed efficiency. The depression of acetate and butyrate production by MON with a concurrent increase in propionate and valerate is of practical benefit in high-producing dairy cows. Studies showed that feeding MON from 1 week prepartum to 2 week postpartum is effective in lowering blood ketone levels and increasing blood glucose during this critical period of the production cycle.

25-Hydroxy-vitamin D_3 (25 OHD_3)

A high-pressure liquid chromatographic method was developed to determine tissue levels of the vitamin D metabolite, 25 OHD_3. The procedure involved saponification followed by chromatography to remove extraneous material. Quantitation of 25 OHD_3 was achieved in samples that contained as little as 2 ng/g.

Vitamin D is converted in the liver to the active metabolite 25 OHD_3. In a study on sheep, the effect of ultraviolet irradiation (UVR) of the skin on plasma and tissue levels of 25 OHD_3 was determined. In response to UVR, plasma levels of 25 OHD_3 increased from day 1 to day 25 and then a steady-state level was reached even though exposure continued until day 70.

Selenium (Se)

Retained placenta is a serious disorder in dairy production affecting 15% of the national herd. Over a 3-year period involving 627 parturitions, the ARC breeding herd was used to study the relationship of Se status to retained placenta. The herd was divided prepartum into groups: group 1 received no treatment; group 2 received a single intramuscular dose of 45 mg Se and 2040 IU of vitamin E from 21 to 10 day preparturition; and group 3 was intraruminally administered with two 30-g pellets, each containing 10% elemental Se. The 22.7% incidence of retained placenta in group 1 was not reduced in groups 2 or 3.

Commercial calf milk replacers are usually inadequate in minerals such as Se, Fe, I, Cu, and Mn, and manufacturers supplement their products with salts of these elements. A higher level of Se may better protect against nutritional muscular dystrophy. However, it is not known how much dietary Se can be tolerated. In a 6-week study with 40 male calves, their tolerance to high Se concentrations was tested. Diets based on skim milk powder contained either 0.2, 1.0, 2.0, 5.0, or 10.0 ppm Se as selenate. The level of 0.2 ppm is the upper limit currently allowed in commercial replacers. Concentrations under 10 ppm had no effect on average daily gain (ADG), DM intake, or feed efficiency. At 10 ppm, calves had reduced ADG and feed efficiency and lowered blood hematocrit. Digestibility of feed DM, crude protein, and fat were not affected by Se concentration. Se levels in blood, bile, liver, and kidney increased appreciably as dietary Se was raised, but muscle increases were relatively small. Necropsy revealed no gross abnormalities.

Forage preservation

In Ontario and Quebec widespread rains during the harvesting season make it difficult to properly preserve hay-crop forage. Farmers often store forage as over-dried haylage and moist hay. These forages overheat in storage, deteriorate in quality, and result in reduced milk production. Methods have been developed for preparing good quality wilted-alfalfa silage (AS) by ensiling it at 35% DM and high-moisture alfalfa hay (AH) at 75% DM by treating it with 0.4% propionic acid. These methods are less dependent on weather than drying of low-moisture hay.

In complete, mixed diets AS and AH were included at 30% of DM to replace corn silage. Cows in early lactation performed well and produced milk at 30.9 and 30.1 kg per day for AS and AH diets, respectively, compared with 29.3 kg per day for a low-fiber control diet based on urea-treated corn silage and a limited amount of well-dried hay. For all diets the consumption of DM was similar at 21.3–22.4 kg per day, and about 21% of gross energy consumed was secreted as milk. There were some indications that a higher proportion of dietary CP of AH diet was secreted into milk, but there was no difference in total production of milk protein.

Zinc (Zn) absorption

A high proportion of ruminant diets are inadequate in Zn. To achieve optimal production, diets deficient in Zn are supplemented with it in various chemical forms. With the use of a zinc chloride supplement, the absorption and secretion of ^{65}Zn in the stomach and intestinal tract were studied in three sets of two and three sheep that were exchanging digesta via duodenal reentrant cannulas and automatic digesta samplers. One sheep from each of the three-sheep sets was dosed intraruminally with ^{65}Zn, whereas one sheep from the two-sheep sets received an intravenous dose.

Measurements of ^{65}Zn in blood plasma from intraruminally dosed sheep showed that there was no apparent absorption from the stomach region. Data from the sheep receiving radioactive digesta intraduodenally showed that mean apparent absorption of ^{65}Zn was 7.0%, and mean true absorption was 10.3%. There was a large variation in endogenous recycling of ^{65}Zn into the stomach region. Secretion of ^{65}Zn into the stomach and intestinal regions in the intravenously dosed sheep was calculated on the basis of total recovery over 10 days in the digesta and feces. For every molecule of Zn secreted into the stomach, 2.1 molecules were secreted into the intestinal tract region. The study concluded that sheep utilize only 10% of Zn in the diet.

DAIRY CATTLE BREEDING AND PRODUCTION

National cooperative dairy cattle breeding project (NCDCBP)

Comprehensive analyses of lifetime performance records of pureline and crossline genetic groups in NCDCBP were initiated and will provide definitive economic comparisons of the breeding systems studied, as a guide to future breeding programs to increase dairy production efficiency. The proportional hazards model with censoring was used to assess factors affecting length of herd life. Censoring or data with incomplete survival time ranged from 29 to 40%. Median estimated herd life (MEHL) was 3.6 years or 1.5 lactations for animals alive at first freshening and increased to 3.9 years or 1.9 lactations for those completing a first lactation. At 308 days postpartum, crossbred females had a MEHL that was 21 weeks longer than the mean of purelines. Individual milk yield was positively associated with longevity and had the greatest impact. Abortion and days-to-last-insemination were negatively associated with survival but with a lesser effect. Age-at-last-insemination had a negative relationship with survival among virgin heifers. A sire's estimated breeding value (SEBV) for milk yield had a small positive effect on MEHL for the data sets to freshening. There was evidence that large heifers had increased longevity, but that relatively high feed intake postpartum was associated with reduced length of herd life. Objective measures of conformation, particularly of the udder, were not important in determining herd life.

Factors associated with survival to first and second calving and completion of a lactation record were assessed. About 23% of potential heifers were culled before first calving, and 25% of first calvers did not calve a second time. Results from retrospective selection index and stepwise linear logistic analyses of data at birth; 34, 50, and 82 weeks; freshening; and 112 and 308 days postpartum showed that predictability of culling was poor. With few exceptions, survival rates varied significantly among herds and among genetic groups from birth to 82 weeks. Heterosis for the probability of completing a lactation and of survival to second calving was positive and significant at 5–9%. Heavier heifers were more likely to survive to first calving. SEBV for milk and fat, protein, and lactose composition were not important in predicting survival to first calving. SEBV for lactose had a negative influence on survival to second calf. SEBV for milk yield was important for predicting survival to complete a lactation record based on data for heifers alive at 82 weeks of age. At 82 weeks, an increase in age-at-last-insemination was associated with a low probability of survival to first and second calving. After freshening, cows that subsequently became pregnant and aborted their calves had a reduced probability of survival to second calving. As expected, days-to-last-insemination (a measure of fertility) and milk yield had a significant effect on survival or the probability of completing a lactation. It was concluded that there is considerable scope for improved management to reduce culling in early life. Early culling does not bias sire evaluation on first lactation records. Improved reproductive success would greatly enhance overall survival rates. Crossbreeding could have a large impact on herd profitability through increased survival.

Relationships among reproductive traits, body weight, and milk yield

Relationships among reproductive traits, body weight, and milk yield were examined using NCDCBP data. Heritability estimates for heifer and cow reproductive traits were generally low (0–26%), whereas those of body weights at calving and 112 days postpartum, and milk yield, were moderate (24–43%). Heritability of milk production declines from first to second lactation. Heifers with difficult calving had a higher incidence of retained placenta than those with normal calving. Phenotypic correlations between heifer reproduction traits and milk yield during first lactation were generally small at –0.10 and 0.06, respectively. In cows, significant positive phenotypic correlations were observed among reproduction traits. Phenotypic correlations between heifer and cow reproduction traits were small and not significant. Difficult calving in heifers impaired reproductive performance after calving, resulting in greater number of days from calving to first and last breeding and leading to a longer calving interval.

Milk protein polymorphism

The effects of four milk protein loci (α_{s1}-, β-, and κ-casein and β-lactoglobulin) on growth and reproduction were studied. The additive effects of gene substitutions at the loci were significant in only 4 of 56 cases for all traits studied. Dominance effects at α_{s1}-, β-, and κ-casein loci were not significant for any traits, with the exception of the β-casein locus on body weight at first calving. Heiffers with AB type of β-lactoglobulin showed greater body weights, measurements, and length of gestation than th AA or BB type, indicating an overdominance effect. Heifers with AB type of β-lactoglobulin were significantly younger at first conception and at first calving and had a fewer number of days-from-first-service-to-conception than the AA or BB type, indicating an underdominance effect. Thus, the β-lactoglobulin locus shows overdominance, underdominance, or no dominance, depending on the traits considered. The four loci contributed more dominance variance than additive variance to total phenotypic variance. This might account for the existence of milk protein polymorphism in the population. The combined genotypes of the four loci showed significant effects on 2 of 14 traits. The effects of the loci on heifer growth and reproduction were smaller than their effects on lactation yields.

Sequential estimation of genetic and phenotypic parameters

Single-trait and multitrait (two-, three-, four-, and five-trait) restricted maximum likelihood (RML) methods were applied to the same set of data with complete information on all traits. Parameter estimates from a data set varied, depending on the type of analysis and on the traits included. Multitrait analysis is required to provide a complete picture of all interrelationships among traits and to maximize accuracy. In contrast, single-trait analysis ignores the possible contribution of other related traits and leads to inconsistent results. The five-trait model analysis through canonical transformation was about 300% more efficient in terms of computer time than single-trait model analysis of the same five traits. Parameter estimates also converged faster under multitrait than under single-trait analysis. Hence, multitrait analysis is strongly recommended.

Genetic parameters of lactation curves

Weekly milk yields of 1022 Holstein heifers from the NCDCBP were used to derive the coefficients of lactation curves by modified gamma and inverse polynomial functions. Genetic parameters for the coefficients were estimated by the multitrait RML method using canonical transformation. The moderate heritability estimates suggest that coefficients of the lactation curve could be changed through selection. Genetic and phenotypic correlations among the lactation curve coefficients indicated that selection for increased milk yield at

308 days would result in a steeper incline in the prepeak portion and a steeper decline postpeak in the lactation curve, and increased peak yield, but a later week of peak yield.

Correlations between yields on test day and retest day

In a study, researchers examined correlations of daily yields of milk and fat and percentage of fat on adjacent days and adjacent test days at various stages of lactation using the ROP program data. The correlation between percentage of fat on test day and the following day (retest day) was low (0.71) compared with correlations for fat yield (0.85) and milk yield (0.96). Correlations between values on either test day or retest day with those on the next test day were 88–90% of those between values on test day and next day for milk yield and fat yield but only 73% for percentage of fat. Correlations for fat test were particularly low for the first test day at <60 days in milk.

Effect of complete dry-cow therapy on mastitis control

Data were analyzed from 297 cows in the Ottawa NCDCBP herd, which received complete dry-cow therapy and subsequently calved. In this study 13.1% of the cows and 7.7% of the quarters had infections at drying off. About 92% of the infected quarters were cured with dry-cow therapy. At the same time, 6.1% of the quarters had new infections during the dry period. Dry-cow therapy enhanced the cure rate of existing infections and reduced new infections.

SWINE PRODUCTION

Naked oats

Naked oats, *Avena nuda*, have potential as a dietary ingredient for pigs. Studies have shown that naked oats, cultivar Tibor, are suitable for partial or full replacement of corn and soybean meal for growing–finishing pigs. Three diets fortified with vitamins and minerals were fed, one containing corn and soybean (diet 1), another with naked oats replacing half the corn and soybean (diet 2), and the third using only naked oats (diet 3). The diets were isonitrogenous and isocaloric, at about 18% crude protein and 18 MJ/kg, on a dry-matter basis, respectively. The dietary lysine content decreased and the sulfur amino acids increased with increasing oat content. Forty-eight grower pigs were individually penned and fed ad libitum to 90 ± 5 kg finishing weight. Diet 2 provided the best average daily gain, and pigs reached market weight about 1 week earlier. Although diet 3 provided a lower yield of lean meat, the meat quality scores were higher for flavor, tenderness, and juiciness than for the other diets. Results suggested that naked oats are better suited as a partial replacement for corn and soybean meal for growing–finishing pigs.

Carcass quality

Preslaughter management plays an important role in determining the ultimate quality of pork. Researchers have assessed, under commercial conditions, the influence of the duration of transport and of the resting period before slaughter on pork quality. Results confirmed the importance of these factors. For both summer and winter months the incidence of poor-quality pork (very pale and pale) decreased with duration of transport, but in winter months, this decrease was accompanied by an increase in the incidence of dark pork. During summer months the incidence of poor-quality pork decreased with increasing length of the resting period. This was true for duration of transport; however, the extent of the improvement was more significant for the pigs transported for less than 1 h. During winter months, a 3-h resting period, compared with no resting period, improved the quality of pork. But, a 3-h resting period for pigs transported for less than 1 h compared with pigs transported for 2 h actually had a detrimental effect, with an increase in dark and pale loins.

Acid-base balance

Dietary undetermined anion (dUA), calculated as Na + K + Ca + Mg – Cl – P – S and expressed in milliequivalents per kilogram, represents a dietary acid or alkaline challenge to the pig. Definition of growth and metabolic responses to dUA may be useful in developing practical guidelines for diet formulation. Growth and balance experiments with pigs have evaluated the response to acidogenic diets, such as those containing elevated Cl levels. Growth trials demonstrated that practical corn–soybean meal diets are optimal for dUA. Balance experiments showed that elevated dietary Cl resulted in a renal acid-base response, with NH_4 excreted in approximate proportion to the acidogenicity of the diet.

Swine behavior

The fighting that occurs when unacquainted pigs first meet can have deleterious effects on the animals' growth and welfare. When this meeting occurs before slaughter, it can lead to a loss of meat quality. Staged contests involving pairs of pigs 5–8 weeks old showed that fights were shorter and involved less biting when the pigs differed in weight by at least 4 kg compared with pairs of similar weight. In groups with a large variance in weight, most fighting occurred between the larger animals, with little fighting between smaller pigs.

Tail-biting is a widespread behavioral problem causing considerable economic loss. Mineral-deficient diets are among the factors that might contribute to tail-biting. In previous work, growing–finishing pigs showed a pronounced but highly variable attraction to the taste of blood, and some pigs chewed avidly on a blood-impregnated object. In current research, pigs were allowed to chew on lengths of plain or blood-impregnated cotton cord. When all mineral additives were omitted from a standard diet of corn–barley–soybean meal, the incidence of chewing on the blood-covered cord greatly increased. Omission of only the salt (0.5%) caused a major increase in the attraction to blood, whereas omission of all other mineral additives had much less effect. Results suggest that inadequate amounts of salt could cause tail-biting to be more persistent and severe once blood has become available from injured tails.

To survive and grow normally, a suckling piglet must defend its teat against habitual encroachment by littermates. This is a particular problem for piglets with a low birth weight, whose competitive ability is poor. From birth, piglets often use their eye teeth as weapons during teat disputes, but to prevent injury these teeth are commonly removed at birth. In a study of 36 litters, piglets having intact teeth were compared with littermates whose teeth had been clipped. In litters of 8 or 10 piglets, the teeth conferred little advantage; however, in litters of 12 piglets, where competition was severe, piglets with intact teeth gained 10% more weight than littermates with clipped teeth.

POULTRY BREEDING

Genetics of poultry meat production

Crippling from all causes to 20 weeks of age and death caused by acute heart failure (flip-over and ascites) to 10 weeks of age were studied in pedigreed broiler sire and dam populations to estimate benefits of selection. Respective incidences of crippling for sire and dam populations were 9.4 and 20.1% for males and 3.9 and 5.5% for females. Corresponding rates of heart failure were 4.3 and 6.4% for males and 1.3 and 0.9% for females. Heritability estimates based on sire variance components were 0.15 and 0.12 for crippling and 0.06 and 0.01 for heart failure for sire and dam populations, respectively. The reduction of heart failure by genetic selection would not appear to be effective. However, genetic selection to reduce crippling may be worthwhile on a family evaluation basis.

Synthetic lines of broilers have undergone selection for five generations to evaluate various multitrait selection programs. Selected traits in sire lines include 28-day body weight, crippling, and either 28–42-day feed efficiency or 47-day abdominal fatness of sibs, or both. In dam lines, selected traits included 28-day body weight, crippling, 28–42-day feed efficiency, and hatching-egg production of pullets to 40 weeks of age. Performance of pure-line progeny indicated that in sire lines, body weight has increased by 80–90 g. Abdominal fatness was reduced by approximately 12%, with evidence of greater reduction in lines selected for improved feed efficiency. Feed efficiency improved 2–3% when selection for low abdominal fatness was excluded but only 1% when this trait was included. In dam lines, selection increased body weight by 80 g, feed efficiency improved by 0.5% in spite of increased body weight, and a slight reduction in abdominal fatness occurred.

Genetics and management studies in egg-laying chickens

Sex-linked genetic effects are important for egg production and other performance traits. Maternal effects are important for early growth rate and effects caused by disease organisms. Large differences between reciprocal crosses were observed in crosses of Leghorn strains. As a percentage of the midparent mean, reciprocal differences averaged 2–8% for adult viability (VIA), 3–8% for hen-housed egg production (HHEP), 3–6% for egg mass (EM), 2% for age at first egg (AFE), 2–3% for egg weight (EW), and 1–3% for eggshell quality (EQ). Mean reciprocal differences were equal to or greater than heterosis for VIA and EQ. Heterosis averaged 1–7% for VIA, 2% for EW, and 0% for EQ. It was concluded that the choice of genotypes for male and female parents had a large effect on the performance of progeny and merited careful consideration in a breeding program.

Reciprocal differences and heterosis are affected by environment and age. In crossing studies that included various stocking rates, heterosis for egg production traits increased as stocking rate increased. Mean reciprocal differences at the high stocking rate were equal to or greater than those at the lower stocking rate, and reciprocal differences between pairs of strains varied considerably. Correlations of mean performance of genotypes at various stocking rates were 0.18 for VIA, 0.72 for HHEP, and 0.72 for EW. Heterosis and reciprocal effects for egg production traits in a second cycle of egg production were greater than those in the first cycle. For example, for HHEP, heterosis increased from 8.4 to 13.0% and reciprocal differences from 3.4 to 6.8%, respectively. Correlations between performance in the first and second cycles based on the mean performance of genotypes were 0.51 for VIA, 0.68 for HHEP, and 0.87 for EW. Thus, heterosis and reciprocal effects are important at high stocking rates and in second-cycle production.

Spurs can predispose birds to injury. In a study of Leghorn females, heritability rates for spur incidence and length were 0.21 and 0.42, respectively. Spur length was negatively correlated with egg production traits, EW, specific gravity, and albumen quality. Genetic relationships were not so clear, and no significant heterosis for spur incidence or length and few reciprocal effects were observed. The results indicate that the primary breeder can reduce spur incidence and length.

Disease resistance genetics

A program has been under way for three generations to eradicate avian lymphoid leukosis (ALV) from three poultry populations consisting of meat-type strains, Leghorn strains, and a mixture of strains. An optical density (OD) procedure for measuring group-specific viral antigen (GSA) in albumen of one egg per hen was used to test ALV infection. Only test-negative hens were used to reproduce each population. The incidence of test-positive chickens doubled in meat-type sire strains and was reduced at least 50% in the other populations. There was a contrast between Leghorn and meat-type hens in the distribution of OD readings. For Leghorns, 70% of the positives were less than 1.2 and 26% were greater than 1.6. Corresponding values for meat-type hens were 85 and 3%, respectively. It was concluded that GSA of endogenous origin may have influenced test results of meat-type hens, giving rise to false positives.

Goose management and genetics

Reliable methods of obtaining high-quality semen from ganders are necessary before artificial insemination can be practiced routinely. Semen production was studied using three housing environments. In treatment 1 ganders were penned in groups of eight; treatment 2 had ganders penned singly; and treatment 3 had ganders penned singly with a goose placed adjacent to and in visual contact with each gander at least 1 h before semen collection. For treatments 1, 2, and 3, 28, 44, and 60 collections were made, with measurable yields of 105, 229, and 152 million spermatozoa per collection, respectively. Thus, ganders penned singly or singly adjacent to a goose produce more useful collections than those penned in a group.

Reliable methods of assessing live geese for lean meat yield are required to expedite genetic improvement in carcass quality. Following slaughter of 53 Chinese and 45 Synthetic males at 18.5 weeks of age, thickness of breast and drumstick meat was measured by needle probe. Breast thickness was correlated with the percentage of total lean meat in the breast (0.38) and legs (–0.32), and drumstick thickness was also correlated with the percentage of total lean in the breast (–0.56) and legs (0.50). These correlations and step-wise regression analyses suggested that breast and drumstick thickness could be very useful in selecting for leanness.

Eggshell quality

Substituting 1,25-dihydroxy-vitamin D_3, the hormonal form of vitamin D_3, for vitamin D_3 in laying hen rations significantly increased egg specific gravity, percentage of shell, egg production, plasma levels of total Ca, and estrogen, but it markedly decreased hatchability of fertilized eggs. Rations containing 3% Ca but no vitamin D supplements resulted in eggs with very thin shells within 4 weeks, thus indicating the rapid depletion of endogenous vitamin D. The results suggest that feeding the hormonal form of vitamin D_3 may improve eggshell quality.

POULTRY NUTRITION

Feedstuff evaluation

A technical bulletin was published that describes the true metabolizable energy (TME) system of feedstuff evaluation. Methodology is detailed, and extensive tables on feedstuff composition, particularly bioavailable amino acid concentrations, are included. The bulletin concludes with a comprehensive bibliography. Worldwide demand from the poultry and feed industries and from scientists is evidence of the wide use of the data and application of the system.

Accurate collection of excreta is an important part of bioassay work, one objective being to obtain excreta uncontaminated by feathers, scale, feed, water, dust, and insects. This goal was achieved by using a harness that holds a plastic bag around the cloaca. Current work shows that the technique has an adverse side effect, as it impairs the voidance of excreta energy. The problem is of practical importance in the search for greater accuracy and precision when evaluating feedstuffs. Furthermore, it is important to note that even apparently simple techniques must be thoroughly tested and evaluated.

Nutrient utilization

Protein and fat accretion by broiler chicks is affected by dietary lysine concentration, even when feed intake is constant. The ratio of dietary lysine to TME_n (TME corrected to zero nitrogen balance) elicits similar responses, irrespective of whether the diet is high or low in added fat. Thus, the presence of dietary fat will not necessarily induce an adverse effect on carcass composition. An earlier finding that the lysine of L-lysine HCl is not always completely bioavailable was confirmed. In a parallel study DL-methionine was, for practical purposes, completely bioavailable although the difference from 100% was statistically significant ($P < 0.01$).

Carcass analysis

Techniques for examining poultry carcass composition have been developed. When the sum of crude protein ($N \times 6.25$), neutral lipids (ether extract), and ash was subtracted from carcass dry matter there was an unexplained residue of about 2–5%. Assuming that much of this residue was phospholipid, a simple assay technique reduced the unexplained residue to approximately 1%. The assay involved extraction with chloroform–methanol and correction of the extract weight for $N \times 6.25$ content to obtain an estimate of total lipids.

Naked oats

Naked oats, *Avena nuda* cultivar Tibor, were evaluated as an ingredient of laying hen diets. The low-fiber grain was substituted for corn and soybean meal at levels of 300, 600, and 800 kg/t to provide diets equal in content of TME_n, lysine, and methionine. For naked oats of the crop year 1984, egg yield for the first 6 months in lay was the same at all levels of oat substitution. Percentage of egg production per hen per day for the three treatments was 76, 75, and 73%, but egg size was 56.9, 57.1, and 57.8 g, respectively. The latter change had a positive effect on egg grading. For crop year 1985, the diet of 800 kg/t decreased egg yield and the percentage of egg production per hen per day, but egg weight was higher than for the corn-soy diet. Except for yolk color, which decreased with dietary level of oats, neither egg quality nor shell strength were influenced by the ingredient. For 1985 oats, feed efficiency tended to be higher in diets at levels of 300 and 600 kg/t than at 800 kg/t. The performance of hens fed naked oats supplemented by only vitamins, minerals, and alfalfa was about 10% inferior to performance with a corn–soy diet. Further supplementation with lysine and methionine resulted in egg production and egg weight equal to and feed utilization superior to controls.

The role of β-glucan and glucanase in the growth inhibition of young chicks was studied. The nutritional effects of oat gum and oat brans that had been prepared by the Food Research Centre showed that growth inhibition was increased when β-glucan was added as gum or as bran and decreased by increasing enzyme levels. These comparisons indicated that endogenous enzymes contribute to a reduction of growth inhibition by dietary β-glucan. Research indicated that naked oats have a higher nutritional value than other grains, and their potential as a dietary ingredient for laying hens will encourage wider use of this feedstuff.

SHEEP PRODUCTION

Studies using record of performance (ROP) data

Lamb growth performance and ewe productivity were determined for established sheep breeds in Canada from field data supplied to the federal–provincial ROP program. Breeds represented were Suffolk (Su), Hampshire (Ha), Oxford (Ox), Lincoln (Li), Columbia (Co), Rambouillet (Ra), Dorset (Do), Corriedale (Cr), Leicester (Le), North Country Cheviot (NCC), Southdown (So), and Finnish Landrace (FL). Lamb growth performance was highest for Su followed by Ox and Ha. Performance was intermediate in the FL, Do, NCC, and Ra and lower in the remaining breeds.

Ewe productivity was evaluated on the basis of prolificacy at lambing and at weaning, and on average and total lamb weight per ewe at 50 and 100 days old. Only the Su, Ha, Ox, Co, Ra, Do, and NCC were evaluated, because of insufficient sample size for the others. Although breed differences were not significant in order of ranking, Co, Ha, Do, and NCC had higher prolificacy at lambing than Su. Breed rankings for prolificacy at weaning were Do, NCC, Ox, Co, Ha, Ra, and Su. Ox and Do had higher average lamb weights than Su at 50 and 100 days of age. Do, Ox, and NCC had higher total lamb weights than Su at 50 days of age, and at 100 days of age the breed rankings were NCC, Do, Ox, and Su. Ha, Ra, and Co had lower ewe productivity than Su, and their rankings were similar for all traits.

Development of specialized synthetic sire and dam strains

Genetic and phenotypic parameters of carcass traits were determined for ram lambs reared artificially in a controlled environment. Paternal half-sib estimates of heritability at 36 kg body weight and 116 days of age were moderate to high, ranging from 0.38 to 0.67 for shoulder and leg (trimmed and lean), total trimmed retail cuts, total lean, chilled carcass weight, and lean weight per day. Estimates of phenotypic and genetic correlations between these traits showed a significantly favorable relationship, indicating their usefulness as criteria in selection for meatiness. Heritability estimates for front, back, and total "in rough" retail cuts, trimmed loin cuts, lean in rack and loin, kidney fat weight, and dressing percentage ranged from −0.19 to 0.27. Estimates for loin, rack, front, back, total retail cuts, kidney fat weight, dressing percentage, and chilled carcass weight per day showed lower and nonsignificant relationships with total trimmed retail cuts or total lean.

Serum levels of follicle-stimulating hormone, luteinizing hormone, and prolactin were determined at 6, 8, and 12 months of age, in 238 young rams representative of the ARC synthetic sire and dam strains and the FL control breed. Two years later, serum hormone levels, scrotal size, and semen quality were determined in 25% of the rams. Levels of follicle-stimulating hormone of young rams at all ages were correlated with scrotal size. Testosterone levels at 8 months were correlated with adult scrotal size and at 12 months with number of adult sperm. These results indicate the potential of endocrine parameters in young rams as selection indicators for predicting subsequent adult sperm-producing capacity.

Reproductive physiology

Follicular growth and ovulation. Studies on the role of follicular steroids in the growth and maturation of preovulatory follicles continued, using as the experimental model the prepubertal gilt treated with 750 IU of pregnant mare's serum gonadotropin (PMSG) and 72 h later with 500 IU human chorionic gonadotropin (hCG) to produce a population of uniformly developing follicles that will ovulate at a predictable time after hCG treatment (42 ± 2 h). Culture of isolated and dispersed granulosa and theca interna cells from follicles obtained 72 h after PMSG treatment showed that 17 α-hydroxylase and $C_{17,20}$-lyase enzymes resided principally in the theca interna cells. The lack of androgen production by granulosa cells was due to the absence or very low activity of these enzymes.

The avidin-biotin immunoperoxidase method and antisera to purified porcine relaxin (RL) was used to localize RL in sections of follicles. Light intensity immunostaining was observed in the theca interna of follicles obtained 48 and 60 h post-PMSG. At 72 h post-PMSG, RL immunostaining in the theca layer was more intense. The intense thecal immunostaining was also evident 84 and 96 h after PMSG. RL immunostaining was not evident in follicles from untreated gilts; follicles 24 h after PMSG; small, healthy, or atretic follicles; or granulosa cells. This study supports the hypothesis that the theca is the primary source of follicular RL and provides evidence for a paracrine role for RL in the ovulatory process.

Processing procedures for ram semen. Glycerol is an effective cryoprotective agent for freezing ram semen. The addition or removal of glycerol can adversely affect spermatozoa survival because of the osmotic effect. Studies showed that spermatozoa survival was higher in semen diluted initially with Tris-fructose diluent, if glycerolated diluent was added after cooling to 5°C than at 30°C. However, there was no difference in spermatozoa survival if the diluent was added at one time or dropwise over 30 min, provided sufficient time (15 min) was allowed for glycerol penetration of the spermatozoa membrane before freezing. Also, spermatozoa survival after thawing was similar when the semen was diluted in one step or in a dropwise addition of diluent over 20 min. From a practical standpoint, the addition of diluent in one step can reduce the processing time.

Alternative freezing procedures for ram semen have been developed and evaluated. Pregnancy rates of 73, 67, and 80% were obtained after double insemination of synchronized ewes with frozen-thawed semen processed by variations of the new procedure. In comparison, fertility of ewes inseminated with fresh semen was 93%. These preliminary data indicate that an acceptable fertility can be achieved by artificial insemination using frozen-thawed semen processed by the improved procedures.

Manipulation of photoperiod. In rams exposed to alternating cycles of 8 and 16 h light daily, testicular activity as monitored by serum hormone levels, scrotal size, and semen parameters was characterized by rhythmic cycles of maximum and minimum activity, which corresponded to the combined number of months in a repeating photoperiod. If rams were exposed subsequently to a prolonged period of 8 h of light daily, the rhythmic changes in scrotal size continued for at least one cycle before being sustained at near maximum levels. In contrast, the rhythmic changes in scrotal size persisted for at least three cycles if the rams were subsequently exposed to a prolonged period of 16 h of light daily. In both situations the magnitude of the cyclic changes was reduced. Sperm production, semen quality, and scrotal circumference in rams exposed to 16 h of light daily were lower than in rams exposed to 8 h of light daily.

ANIMAL FEED SAFETY AND NUTRITION

Pesticide residues

Deltamethrin (DLM). An industry-sponsored study on the fate and residues of DLM and its two major metabolites was completed. Lactating cows were fed 2 or 10 ppm of DLM, twice daily for 28 days. Very little residue was secreted in milk or deposited in edible tissues and organs. The maximum residue in milk was 60 ppb for cows fed DLM at 10 ppm. Subcutaneous and renal fat had DLM residues at 280 ppb at 10 ppm feed intake when cows were slaughtered within 24 h after the last treatment. In muscles the residues were lower than 10 ppb. Residues dissipated rapidly when contaminated feed was removed. The data indicate that proper use of DLM should not produce unwanted residues in milk, meat, and other dairy products.

Cyfluthrin and cyhalothrin. Unlabeled cyfluthrin, cyhalothrin, and four of their major metabolites have been synthesized. Spectroscopic and analytical data have been recorded. A gas-chromatographic method was developed for detection of cyhalothrin and its two major metabolites in milk, fat, and muscle.

Mycotoxins

The effects of oral deoxynivalenol (DON) on pigs and the elimination pattern of DON and its metabolites in lactating dairy cattle were determined. The results led to in vitro production of the deepoxy metabolite of DON, DOM-1, to metabolism studies using rat and pig hepatic microsomal preparations, and to in vivo metabolism studies with rats and pigs.

Fusarium graminearum produces DON as well as zearalenone (Z), an estrogenic mycotoxin. Three concentrations of DON to Z (0.7:0, 3.1:0.05, and 5.8:0.1 ppm) were fed to 5-week-old castrated male piglets and to female piglets. Feed intake and weight gain varied inversely with the dietary levels of DON to Z during the first 4 weeks. Males had a lower weight gain than females fed the same diet. Necropsy revealed no significant lesions in either sex. DON was found in trace amounts (<50 ppb) in the plasma, urine, and gastrointestinal contents, but not in other organs. Three lactating dairy cows were fed diets contaminated with DON at 66 twice daily for 5 days. DOM-1 up to 26 ppb, but no DON, was found in the milk. Aproximately 20% of the DON fed was recovered in urine and feces as DOM-1 and DON. Large amounts of glucuronides of DON and DOM-1 were found in urine.

In vitro incubation of 1500 mg DON from corn extract with rumen microorganisms yielded 340 mg DOM-1 after extraction and purification. DON and DOM-1 were incubated with rat hepatic microsomes and NADPH. Neither DON nor DOM-1 disappeared from the microsomal incubates, suggesting that neither compound is bioactivated to a more toxic product or oxidized to a lesser toxic compound by the rat hepatic mixed function oxidase system. Possible glucuronidation was evaluated using in vitro systems with rat and swine hepatic microsomes. DON glucuronidation was also evaluated in vivo. No evidence of glucuronidation of either DON or DOM-1 was found.

Results using radiotracers indicated that DON is poorly absorbed by ruminants and poultry, and that residues are not transmitted into milk of lactating sheep or to edible tissues of poultry. With prolonged consumption of DON at dietary levels as high as 20 mg/kg, some accumulation in eggs from laying hens did occur, although residues rapidly decreased once contaminated feed was removed. DON was very efficiently absorbed in swine, and preliminary kinetic data suggested that whereas a single exposure was rapidly eliminated from the animal, upon continuous exposure, some accumulation of DON in tissues probably occurred. However, tissue residues occurring at typical dietary contamination levels of <5 mg/kg should present no concerns about human health. Z, while poorly absorbed in swine, still exerted estrogenlike properties even at low dietary levels of 1 mg/kg. Elimination of Z from swine was very slow, as it appeared to undergo extensive enterohepatic recycling.

A chick embryotoxicity bioassay, developed previously at ARC, has been used to determine relative levels of toxicity of mycotoxins and metabolites isolated from *Fusarium*-contaminated crops. There is increasing information suggesting that the toxic signs produced in animals fed contaminated diets are not due to the routinely assayed-for mycotoxins but possibly to a combination of unidentified mycotoxins and phytotoxins. The chick embryo test can be used to determine the toxic potential of certain feedstuffs.

Chemical analysis indicated about 45% of the total DON in ears of corn was located in kernels when the ears were infected by inserting toothpicks contaminated with *F. graminearum*. In naturally infected ears, about 63% of the DON was present in the kernels. With Z, however, less of the mycotoxin occurred in the kernels of naturally infected ears than in those inoculated with pure cultures (26 versus 32%, respectively).

Fats and oils

Studies are in progress to evaluate the nutritional and toxicological properties of canola oil for use in infant formulas. Piglets were chosen as the test animal because of their similarity to humans with regard to dietary fats and cardiovascular responses. Preliminary results indicated that piglets will eat milk replacers containing fats with up to 40% erucic acid, although growth rate was somewhat depressed at this high level.

Methods for qualitative and quantitative analyses of lipids using the Iatroscan were completed. A method is now available for analyzing very small amounts of lipids on $CuSO_4$-impregnated chromarods. It is particularly suitable when a complete and accurate lipid profile of a large number of samples is required. The complex lipids of *Methanobacterium thermoautotrophicum* were analyzed. A new aminophospholipid was discovered that showed a remarkable stability to acid hydrolysis. The stability of certain aminophosphate esters in biological systems could have physiological significance in cardiac lipids where similar aminophosphate lipids occur.

Experiments are in progress to study the buildup and metabolism of fat by developing fetal pigs. The relative proportions of ash, nitrogen–protein, and lipid extract in fetal carcasses did not change during gestation. In addition, varying the amount or type of fat in the sow's diet did not affect fetal pig body composition. An extensive review of porcine fat metabolism was completed. In swine from newborns to growing animals, changes in body composition are well documented and many studies have measured rates of in vivo fat synthesis and degradation. The buildup of fat that occurs in newborn pigs is a complex interaction of diet and metabolism. At present it is not possible to predict how much fat an individual pig accumulates as it grows.

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Departures

I.J. Bassett, B.A. Retired	Hay-fever plants, palynology, weeds
A. Mutuura, B.Sc., Ph.D. Retired	Tortricidae (leafroller moths)
D.M. Wood, B.A., M.A., Ph.D. Retired	Tachinidae (parasitic flies), Culicidae (mosquitoes)
B.N.A. Hudson, B.Sc., Ph.D. Seconded to Program Coordination Directorate	Chemical taxonomy of insects, polymorphic enzymes
G.A. Neish, B.Sc., Ph.D. Seconded to Program Coordination Directorate	Mycotoxin fungi
R. Matsuda, B.A., Ph.D., D.Sc. Died 10 June 1986	Comparative morphology and evolution

HONORARY RESEARCH ASSOCIATES

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L.A. Kelton, B.S.A., M.Sc., Ph.D.	Miridae (plant bugs), Anthocoridae (flower bugs)
J.F. McAlpine, B.S.A., M.Sc., Ph.D.	Lonchaeidae (lance flies), Chamaemyiidae (silver flies)
W.C. McGuffin, B.A., M.A., Ph.D.	Geometridae (geometer moths, loopers)
D.B.O. Savile, B.S.A., M.Sc., Ph.D., D.Sc., F.R.S.C.	Plant rusts
G.E. Shewell, B.Sc., M.Sc.	Lauxaniidae (lauxaniid flies), Calliphoridae (blow flies)

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INTRODUCTION

The Biosystematics Research Centre (BRC) provides Agriculture Canada, other departments and agencies, and their clients with a unique centre of knowledge in systematics for dealing with scientific, economic, and social problems relating to insects, mites, spiders, plant parasitic nematodes, weeds, crop plants, native plants, plant parasitic, and biodegrading fungi. The centre provides Canadians with an expert team of scientists and technicians who maintain and update an information system, ensuring that the identity of any of these organisms can be determined accurately and that appropriate data on their biology and impact are quickly available. The centre is responsible for the flow of biosystematic information across Canada and between Canada and other countries. The following broad aims guide the Biosystematics Research Centre in its operations: to conduct research to discriminate among species of organisms and correctly name organisms that occur in Canada or are otherwise of importance to Canadians; to contribute to science and its uses by developing natural classifications and interpreting evolutionary relationships; to develop and maintain the national collections of living or preserved organisms from Canada and elsewhere to provide a reference base for biosystematic research on diversity and distribution, and for identification purposes; to provide a national identification service for clients, publish guides to help others make identifications, and supply relevant information; to provide inventories and studies on flora and fauna for selected regions, habitats, or host groups to permit effective assessment and monitoring of environments, their quality, and their changes; to provide leadership and cooperation in the development of biosystematics in Canada by making staff available for training and other educational purposes.

A publication entitled *Systematics in Agriculture Canada at Ottawa 1886–1986/La recherche en systématique à Agriculture Canada, Ottawa de 1886 à 1986* was published early in 1986.

Reprints of publications are available from the authors. Correspondence on other matters should be addressed to the Director, Biosystematics Research Centre, Research Branch, Agriculture Canada, Ottawa, Ontario, K1A 0C6; Tel. (613) 996-1665.

Robert Trottier
Acting Director

CLASSIFICATIONS

A total of 119 scientific papers and manuals were published on the systematics, biology, biogeography, morphology, and ecology of Canadian fauna and flora.

Insects

Hemiptera. A manual on the leafhoppers of fruit trees in Canada was completed, and work is progressing on the first of a planned three-volume guide to the leafhoppers of Canada and Alaska. Study of previously overlooked anatomical characters of female leafhoppers yielded data that are helping to improve the generic classification. Analysis of the leafhopper fauna of Newfoundland and Cape Breton provided additional evidence of an offshore glacial refugium. Modification of an electronic digitizing system for collecting standardized morphometric data resulted in new insight on the taxonomy of grain aphids (genus *Shizaphis*). Work continued on the text and illustrations for a handbook on the genera of aphids in Canada.

Hymenoptera. A morphometric study made possible the recognition of *Agrypon flaveolatum*, an ichnuemonid parasite introduced to control the apple winter moth but previously indistinguishable from native species of the genus. Revisions were completed on the 41 world genera of Inostemmatinae, parasites of gall midges, and the 104 New World species of *Alabagrus*, parasites of pests of various crops. Handbooks were prepared to enable recognition of the 125 genera of sawflies in Canada and of the parasites of insect pests of sunflowers. A catalog was prepared of the world species of the braconid subfamily Agathidinae (parasites of larval Lepidoptera), and studies were initiated in order to revise the species of the *Tenthredo originalis* group of sawflies, the species of *Homaspis* (ichneumonid parasites of conifer-feeding sawflies), *Spilomicrus* (proctotrupoid parasites of muscoid flies), and the genera of Eupelmidae (chalcidoid parasites of various crops and trees).

Diptera. Editing of the second volume of the *Manual of Nearctic Diptera* was completed, and publication of this major work is expected early in 1987. The third and final volume was submitted to Research Program Service for editing. Handbooks on flower flies (Syrphidae) and horse flies (Tabanidae) of Canada are near completion. Discovery of male specimens of the genus *Austroconops* contributed important new data for reassessment of the phylogeny of biting midges (Ceratopogonidae). Taxonomic revision of the large syrphid genus *Platycheirus* and an extensive review of the chironomid subfamily Orthocladiinae were completed.

Coleoptera. A bibliography of the world literature on bark beetles (Scolytidae), a review of the water scavenger beetles (Hydrophilidae) of Canada and Alaska, and a manual on the stored-product beetles of Canada were completed. A newly discovered species of wingless and eyeless rove beetle was described from soil in central Alaska, providing further evidence that this region was an unglaciated refuge for plants and animals during the Pleistocene. Studies are progressing on the beetle fauna of arctic North America, the leaf beetles of eastern Canada, the weevil genus *Sitona*, and the rove beetle genus *Philonthus*.

Lepidoptera. Investigation of the classification and zoogeography of northern cutworm moths (Noctuidae) continued to focus on the relationships between the fauna of North America and the Old World, especially the USSR. Morphological study of hybrid populations of spruce budworm advanced the knowledge of this important species complex in Canada. Work is progressing on monographic treatment of the butterflies and moths of arctic North America.

Arachnids

Mites. A major revision of the genera of Tarsonemidae was completed, and a review of the associations of parasitic larval water mites with their host aquatic insects was published. Taxonomic revisions of soil-inhabiting mites of the family Unduloribatidae and the genera *Propelops* and *Ametroproctus* were completed. Continuing study of oribatid mites in northern Canada provided further insight into the interrelationships of the nearctic and palaearctic fauna. Investigation of arrenuroid water mites resulted in the discovery of many new species and the recognition that mites of this group form an important component of the arthropod communities of spring and groundwater habitats in Canada. Work is continuing on a review of mites of the eriophyoid genus *Nalepella*, pests of coniferous trees.

Spiders. Faunal treatments were completed on the wolf spiders, lynx spiders, and nursery-web spiders of Canada.

Nematodes. New cutworm hosts were discovered for lethal nematodes of the genus *Neoaplectana*. A potential nematode vector (genus *Xiphinema*) of virus diseases was found in British Columbia, and new records of the pine wood nematode were found in western Canada.

Vascular plants

Barley cultivars were investigated, and a new classification scheme with two cultivar-groups was proposed. The use of endospermic starch granules for the identification and characterization of *Hordeum* species was assessed. Systematic studies toward a comprehensive monograph of *Medicago* are continuing. New cytotypes of *Artemisia* in North America were discovered. The morphology, cytology, and cytogenetic properties of leafy spurge (*Euphorbia esula* L.) were described and assessed. Relationships between aquatic plants and water chemistry in acid lakes were reported. Research was completed on a major aquatic weed, *Elodea*, of both irrigation systems and recreational waters. A classification of rushes and sedges from pastures was completed. Work on the flora of the Yukon Territory is nearing completion. Studies in Johnson grass in Ontario indicated that rhizome depth was a critical factor in determining differential winter survival. Low levels of isozyme variation were detected in triazine-resistant populations of redroot pigweed as compared with susceptible populations. Very low levels of isozyme variation were detected in 110 world-wide accessions of proso millet varieties and weedy strains. A taxonomic revision of the genus *Sinapis* was completed. The *Manual of Grasses of Canada* is well under way, with 50 species treated and illustrated in detail. The *Poa labradorica* complex was studied in the field and in the laboratory.

Fungi

The *Compendium of Plant Disease and Decay Fungi in Canada* was published. This work contains nearly 30 000 entries, which record the fungi that attack about 600 genera of crop and native plants. Numbers 301–310 of the identification guide series *Fungi Canadenses* were published.

Mushrooms. Studies revealed that the Xerulaceae is a distinct family characterized by the presence of sarcodimitic tissues in most genera. Promising new anticancer antibiotics are formed almost exclusively by genera in this family, a fact obscured by previous taxonomic schemes, which failed to take full account of anatomical details of the sterile tissues. Study of *Xeromphalina campanella* (Fr.) Kuhner & Maire (Xerulaceae), one of the commonest softwood-decaying agarics in Canada, has been expanded to a revision of the genus in Canada. The sterile thalli of species in the genus *Batrydina* can now be identified using a key published in the book entitled *Arctic and Alpine Mycology*. A revision of the mushroom genus *Crinipellis* in Canada was published.

Mycorrhizae. Glomus constrictum Trappe, *G. macrocarpum* (Nicol. & Gerd.) Gerd. & Trappe, and a new species of vesicular arbuscular mycorrhizal fungus, *G. pustulatum* Koske, Friese, Walker, & Dalpé, were described. Several species of *Oidiodendron* (Hyphomycetes) and *Myxotrichum* (Ascomycetes) were verified as ericoid mycorrhizae.

Mycotoxin fungi. Collaborative research was published on trichothecenes, mycotoxins, and molds from injured corn and on toxins from *Fusarium* species from New Zealand pastures. Compilation of the approximately 1100 names of *Fusarium* is nearly complete. A taxonomic treatment was provided for *Fusarium tricinctum* (Corda) Saccardo and for *Eurotium echinulatum* Delacr. (*Aspergillus brunneus* Delacr.).

Parasitic ascomycetes. A paper was completed on the genus *Ascosphaera*, pathogenic to bees, resulting from a 3-year survey (1983–1985) of diseases of the alfalfa leafcutter bee in regions of Canada that produce forage seed. Ragged-brood disease was determined to occur in Canada, although the loose-cell management system employed in Canada apparently contributes to maintaining infection rates at low or moderate levels. Three new species of *Ascosphaera*, all apparently pathogenic to the leafcutter bee, were discovered and described. A treatment of the species of *Mycosphaerella*, occurring on cultivated and wild Brassicaceae in Canada, is nearing completion, and a bibliographic index to the species names published in this large genus is being prepared. A paper on the taxonomy of six species of *Nodulosphaeria* was completed to complement and update a recent revision of Canadian species.

Plant rusts. Descriptions and illustrations were published of *Puccinia sorghi* Schw. (corn rust), *P. triticina* Erikss. (wheat rust), *P. recondita* Rob. (rye rust), and rusts on various Rosaceae.

Saprophytic molds. Beauveria caledonica sp. nov. was described from moorland soil in Scotland. A study of the fungi associated with urea formaldehyde foam insulation was completed and submitted for publication.

Woodrots. A world monograph of the three species of *Dentipellis* contains the first description of the growth of any species of the genus in the laboratory. A monograph of the genus *Syzygosora* was published.

Zoosporic fungi. Computer-enhanced three-dimensional illustrations of the ultrastructure of the organelles of Chytridiomycete zoospores provided a major advance in the classification. Similar investigations with *Lagena radicicola* Vanterpool & Led., a widely distributed cereal parasite and a possible vector of plant viruses, indicated that the present classification of this organism in the Oomycetes may need to be revised.

COLLECTIONS

The holdings of the Canadian National Collection of Insects, Arachnids and Nematodes were increased by 464 500 specimens during 1986, of which 225 400 specimens were identified at least to the generic level and are available for systematic research studies. Major contributions were made by scientists of our research centre, who collected material to support continuing research and technology transfer. BRC staff members conducted fieldwork throughout temperate and arctic North America, and one scientist participated in the University of British Columbia scientific cruise to survey the fauna of coastal British Columbia between Vancouver and Prince Rupert. Four entomologists and an acarologist took part in a survey of an endangered ecosystem in Guatemala as part of a Research Branch centennial project. The major areas of growth were in the collections of parasitic Hymenoptera and in soil and aquatic mites. A total of 5000 specimens were purchased and 113 000 specimens were donated to the national collection in 1986, consisting of material from Canada, the United States, and Europe. Major donations included representatives of 290 species of Old World Lamellicornia from the Hungarian National Museum, 5000 specimens of arrenuroid and aturid water mites from the United States from the Cook collection in Detroit, some 25 000 butterflies from Manitoba from the Gibbon collection, and several thousand specimens of insects and mites from Vietnam collected by Dr. M. Zacharda. Requests from scientists around the world for the loan of material from the Canadian National Collection resulted in 221 loans of approximately 76 500 specimens. Many scientists and students from various parts of the world, including Canada, the United States, Great Britain, and Australia visited the Canadian National Collection in 1986 to study and curate specific groups. The CanaColl Endowment Fund and the CanaColl Development Fund supported 12 visiting scientists, who curated portions of the national collection. Preparation of insect and arachnid specimens were carried out with the assistance of two persons employed under a program for the training of the handicapped and six persons employed on the homebound handicapped program. This help facilitated the preparation of material that would otherwise not have been prepared with our present staff. The entire collection of fluid-preserved specimens of insects and arachnids was reorganized during 1986 because of the purchase of modern storage cabinets to replace the inadequate steel shelving units previously in use.

The collections of the Agriculture Canada Vascular Plant Herbarium and the National Mycological Herbarium were transferred from standard metal cabinets to moveable metal shelving units (compactors) during 1986. The new facility was officialy opened by the Assistant Deputy Minister, Dr. E.J. LeRoux, on 8 April 1986. All specimens are now organized in the new compactors, and the additional space gained will permit normal growth of these collections for at least 15 years.

During the year nearly 12 000 new accessions were added to the Vascular Plant Herbarium, bringing the total number of specimens in the collection to about 784 000. A total of 23 gifts of specimens were received, including 1389 specimens. The largest and most important was a gift of 1075 specimens from northern Yukon. Thirty-five loans, comprising 4473 specimens, were sent out to cooperating institutions for study by their research staff. The annotations made on our specimens by these individuals greatly increase their value.

The National Mycological Herbarium grew by 2256 specimens to a total of 251 089. Of the specimens acquired 420 came as exchanges from other institutions. Part of the growth resulted from the donation of 170 specimens as gifts to the herbarium. Loan of material to other institutions consisted of 701 specimens. A major acquisition was received from Dr. H.J. Brodie – some 1200 fungi from birds' nests. Visitors to the herbarium included 34 mycologists from Europe, Asia, and North America.

The Canadian Collection of Fungus Cultures (CCFC) increased its accessioned holdings from 9007 to 9612. The increase was due mainly to material received from the National Identification Service, other establishments, and isolations made by staff members. An endangered collection of *Phytophthora* spp. (37), the Dr. C.J. Hickman Collection from the University of Western Ontario, was acquired. CCFC also acted as a repository for the Winnipeg Research Station, accepting 43 strains of *Ustilago tritici* maintained in seed. The number of requests (687) was more than double that of 1986, with 38% of the total coming from outside Canada. The major users were from Agriculture Canada (28%), industry (16%), universities (34%), and other government departments and individuals (22%). The organisms received were used in biodeterioration studies, fungicide testing, insect biological control, food and animal development, mycotoxin research, plant pathology, enzyme studies in metallurgy, allergen production, and fuels and cancer research.

NATIONAL IDENTIFICATION SERVICE

Insects, mites, spiders, and nematodes

A total of 1036 shipments were received; 67 807 specimens of insects, mites, spiders, and nematodes were identified in 1986. The main clients were Agriculture Canada (31.5%), provincial governments (23%), and Canadian universities (20%). Briefly, some departmental projects supported this year by the National Identification Service (Zoology) included the following: biological control agents of forest insects (St. John's), economic insect survey (St. John's), biological control of alfalfa blotch leafminer (Charlottetown), fruit insects investigations (Kentville), field crop investigations (Kentville), pine wood nematode survey (Fredericton), role of aphids in the spread of virus diseases (Fredericton), population studies on the spruce budworm (Sainte-Foy), effects of pesticide treatments on nontarget arthropods in apple orchards (Saint-Jean-sur-Richelieu), insects of canola and soy (Saint-Jean-sur-Richelieu), onion maggot parasite–predator monitoring program (London), control of leafminers in vegetable crops (Harrow), integrated pest management of fruit trees (Vineland), thrips on greenhouse ornamental plants (Vineland), forest insect and disease survey (Sault Ste. Marie, Ont.), insect parasites of the pea aphid (Winnipeg), natural control of stored-product pests (Winnipeg), biological control of weeds (Regina), nematodes of wheat seeds (Regina), oilseed crop insect pests (Saskatoon), wheat midge project (Saskatoon), cereal crop insects (Lethbridge), cutworm ecology and management (Lethbridge), pictorial guide of forest and shade tree insects of the Canadian prairies (Edmonton), management of apple insects in the interior of British Columbia (Summerland), insect pests of berry crops (Vancouver), cone and seed insect studies (Victoria), forest insect and disease survey (Victoria), spruce weevil biological control (Victoria).

Vascular plants

During 1986, 11 017 collections of vascular plants were identified. Major users of the service were Canadian universities (33%) and Agriculture Canada (23%). The identifications provided to Agriculture Canada research stations, universities, and provincial departments were associated with host plants of insects, animal habitats, archaeological digs, northern vegetation surveys (Herschel Island), long-term evaluation of regeneration and restoration (Northern Wells pipeline), weed control in forest tree nurseries, vegetation studies on plots of the acid rain national early warning system and on burnt-out blueberry land in the Maritime Provinces, carrying capacity of native range pastures, and pollen in honey samples from western producers. Increased assistance was provided to Plant Health Division, Food Production and Inspection Branch, in the identification of plant material and information on origin and distribution of weeds. Many enquiries were received from other federal departments on the following: interception of fibrous material (Customs and Excise Canada); seeds recovered from the crops of birds killed by aircraft (Transport Canada); identification of rare plants (Parks Canada); and identification of material used as exhibits in criminal cases for forensic laboratories (RCMP). A significant number of enquiries were also received from the Poison Control Centre for the identification of plants suspected of poisoning and from the Ontario Ministry of Agriculture and Food for the identification of crop weeds.

Fungi

A total of 3179 collections and cultures of fungi were identified during 1986. Principal users of the service were the general public (34%) and Agriculture Canada (23%). A significant number of enquiries were received from the Poison Control Centre and from other hospitals for the identification of mushrooms suspected of poisoning. Agriculture Canada research stations, other government departments (provincial and federal), and universities received assistance in the following areas: identification of fungi relating to diseases and storage problems of potatoes and lettuce, spruce budworm–fungal relationships, plant–microbial interactions, bioherbicides, and diseases of intensively managed forests and plantations in the Maritime Provinces. In Ontario and Quebec some enquiries were related to postharvest pathology, long-term storage of cabbage, mycorrhizal fungi, heavy metal fungi in soil, alfalfa diseases, tomato crown and root rot, and diseases of Scots pine in plantations. Enquiries from the West were associated mainly with postharvest diseases of fruit; corn silage problems; forest nursery pathology; diseases of wheat, barley, and vegetables; fungi used by native peoples; a mold and mycotoxin survey; fungi used in the biological control of weeds; a project on leafcutter bees and chalkbrood-foliar mold; stain developing in lumber to be exported; and health problems caused by fungi. Assistance was provided to the Plant Health Division, Food Production and Inspection Branch, in the identification of organisms potentially subject to quarantine and to the RCMP regarding hallucinogenic mushrooms.

In addition to providing identification services, the scientists at BRC contributed their expertise to a variety of other professional activities. These included organizing and presenting workshops on parasitic Hymenoptera and nematodes and regularly supplying essential biological information and advice to practitioners of biological control and programs on environmental impact. Our staff members were actively involved in the education and training of graduate students and technicians in North American universities and colleges and in participating in the organization of scientific meetings such as the 37th annual meeting of the Lepidopterists Society and the 23rd international congress of entomology. Many of our scientists are officers of national professional societies. BRC scientists also played key roles in the affairs of international bodies such as the International Advisory Council on Biosystematic Services in Entomology and in organizing and editing the proceedings of international symposia on insects and fungi.

VISITING SCIENTISTS

More than 50 scientists from institutions and universities around the world visited BRC during 1986 to use the collections and conduct cooperative research with our staff.

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Departures

K. Heng,[1] B.Sc., M.App.Sc. Transferred to Systems and Consulting Directorate, 1985	Systems and programming
C. Vigneault, B.Sc., M.Sc. Transferred to Saint-Jean-sur-Richelieu Station, 31 December 1986	Crop storage
C.J. Williams, B.S.A., M.Sc., Ph.D. Retired 31 December 1986	Head of Statistical Research Section

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[1] Seconded from Systems and Consulting Directorate.
[2] On Education Leave during 1986.
[3] Ph.D. Recruitment Program, McGill University.
[4] Seconded to Audit and Evaluation Branch, 1 April 1986.
[5] On Maternity Leave from July 1986.

INTRODUCTION

The year 1986 concluded a difficult period of work force adjustment over a 4-year period, totaling 25%. Program changes were implemented as a result.

Energy is no longer a priority and phasing out of this program continued. Work is now focused on energy conservation in primary production and is integrated with mechanization and building research. The artificial separation of energy technology created in the 1970s is no longer appropriate. Crop drying and tractor power requirements continue as priorities. Work commenced on collating and reviewing the results obtained through 300 contracted-out projects completed since 1973 at a cost of nearly $35 million. An extensive data base exists in the form of individual contract reports kept by the Canadian Institute for Scientific and Technical Information at the National Research Council. A series of reviews on specific areas of energy research are being released to make access to this information convenient.

Results from the food process engineering program continue to result in patents and adoption of the technology. Several items such as the food blancher and the Cryogran process are now reaching significant levels of commercial production. As a result of leadership by the staff, a standard practice for the establishment of thermal processes for food packaged in flexible containers has been accepted in Canada and the United States.

Progress continued in developing objective methods for grading and inspecting agricultural commodities and food with a view to eventual automation. Several instruments are now undergoing field evaluation, including devices for pork and beef, and one for veal is now in regular use under the department's inspection and regulation program. A number of instruments were completed to improve the measurements and operations required in experiments across the Research Branch. Benefits of accuracy and efficiency from such equipment continue to accrue. A major project was undertaken to develop electronic identification systems for livestock.

Results from the mechanization program are demonstrating new or improved methods for harvesting horticultural crops. Several major projects are coming to completion, including harvesting machinery for processing strawberries, pickling cucumbers, and cauliflowers. Plans are to shift the focus to developing new principles for transplanting (bare root and peat block) under Canadian conditions and a long-term study of the relationship between field equipment power requirements, operation, and soil degradation.

Structures research is contributing to the body of theoretical knowledge of wooden structures design. This will improve the ability of designers to produce safe and economical building structures. The Canada Plan Service met the national priorities for building designs, incorporating up-to-date structural and environmental control technology to provide producers with plans for cost effective animal housing and crop storages. Plans are now produced by an efficient process that increasingly relies on a computer-aided design system that is already linked to one provincial agency. Plans are now based on design modules that can be assembled to suit a variety of requirements. A program has developed to study the interface between the animal and the building environment. This will assist scientists and producers in addressing animal welfare concerns.

Statistical research and services continued to widely support crop and animal research programs by providing experimental design, interpretation of results, and methods of data analysis. Powerful commercial software is being used to a greater extent than before and it is predicted that in the long run these will reduce the need to develop statistical programs in-house. Overall, the program continues to have a great impact on the efficiency and effectiveness of branch research programs.

The engineering scientific and technical information data base continued to expand, food engineering being a new area of focus. Literature searches and reports on specific topics can be efficiently generated. Notable was the publication of the first ever index of all the publications of the Canadian Society of Agricultural Engineers.

Investments in numerically controlled machine tools for the workshop have started to pay off. Components for prototype research equipment can now be manufactured and modified efficiently.

Generally, the programs of the centre continued to contribute to agricultural research and production in a diversity of ways, with primary thrusts in mechanization, buildings, food, instrumentation, and statistical research. A diversity of work was encompassed in the 230 in-house and 58 contracted-out projects managed by centre staff. Results were reported in 120 publications released during 1986. Those that are published and available are listed at the end of the report. A number of miscellaneous and unpublished reports are not listed. These brief statistics represent a very credible achievement for the 26 professionals on strength. These contributions represent the efforts of the key critical masses of engineering and statistical expertise in the Research Branch, making possible the application of advanced technology to problems in both research and agricultural production.

The following report describes briefly some of the specific achievements during 1986. Additional details on these and other items can be obtained upon request from the Engineering and Statistical Research Centre, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6; Tel. (613) 995-9671.

Peter W. Voisey
Director

ENERGY

The low-energy modular wet grain storage system was improved through the development of a bag-dumping device. A system for storing and feeding high-moisture barley, using 1-t sacks, is now in use at several farms in northern Quebec.

In an assessment of the anaerobic digestion program several important conclusions were established. The technology has been taken from the laboratory to the farm in the construction and operation of several farm-scale digesters. It was found that anaerobic digestion cannot be economically justified on Canadian farms. Running a digester is not simple and requires substantial technical support. The refeeding of separated digester effluent, which was highly rated by proponents, has fallen short of expectations. Animal feed intake and rate of gain are both reduced, making this approach impractical supplement feed protein.

A mobile laboratory was built to evaluate the potential of anaerobic digestion to treat various waste streams. Waste streams from a meat-processing plant and a food-processing complex have been evaluated to examine the potential of several types of anaerobic treatment, and as a first stage in the design of a full-scale system. This work is carried out in cooperation with Environment Canada.

A system to pulverize ice from a 300-t ice block produced by using winter coldness was developed, enabling the ice to be packed with fresh vegetables for more rapid cooling and for shipping of high-quality products. Ice produced by a simple system, using cold air during the winter, can now be used as an alternative to mechanical refrigeration for fruit and vegetable cooling during the harvest season. The ice system has a greater capacity, is cost effective, and is applicable to both large and small operators.

It was found that the drying time of corn is related to the pericarp thickness. This points out that the efficiency of dryers could be improved if the airflow rate became a controlled variable rather than just controlling the temperature.

In the development of an automatic guidance aid for self-propelled swathers, computer simulations indicated that an angular rate sensor would be beneficial in preventing the buildup of oscillations on succeeding passes. A control system employing ultrasonics for sensing the cut crop edge, and an angular rate sensor were constructed for a 12.8-m swather. Field tests indicated partial success.

A project to evaluate the sensing technology required for continuous variation of nitrogen fertilizer application rates has shown that the concept has tremendous potential for increasing fertilizer efficiency when the rate of application is matched to the soil requirements.

A study of existing commercial farrowing barns in Alberta revealed that from 50 to 60% of all heat lost through a farrowing barn ventilation system is in the form of latent heat. Actual ventilation rates in the existing barns were generally higher than those currently recommended, but this allowed air quality parameters to reach levels near the acceptable upper limits.

The cleaning of ventilation air heat exchangers is an impediment to their adoption. An automatic cleaning system was developed for a commercial unit. The savings in cleaning labor and increased operating efficiency gave a payback on investment in 2–3 years.

The system developed for utilizing fuel alcohol in a farm diesel tractor has been field tested and found very successful. We now have a simple system that can be adapted to most diesel tractors to utilize most liquid fuels.

A machine developed to separate grain from corn silage for alcohol production has also been applied to make feed rations with different levels of grain for managing feed rations.

Production techniques for Jerusalem artichoke were developed on a farm scale, demonstrating that potato equipment could be used for tuber production with very minor equipment modifications.

FOOD PROCESS ENGINEERING

Canadian and U.S. patents were granted on a process for the separation and concentration of immuno-γ-globulin from porcine blood. Patent disclosures were also filed for an extrusion/microwave process and for a continuous canola fractionation process.

A previously developed food rheometer was modified to conduct studies on food materials, using oscillatory techniques. Work on automated measurement of thermal properties of foods was completed. Laboratory studies were conducted on the distribution of temperature in various-shaped containers heated in a microwave field. Capability in a supercritical extraction system was developed to handle samples up to 500 mL. A study on methods for manufacturing restructured steaks was completed.

A study on physical techniques to determine dilution in juice used in packing whole tomatoes was completed. Techniques to permit detection of diluted juice which does not meet the Canadian standard that states that whole tomatoes must be packed in tomato juice were identified.

A seminar on temperature measurement was organized and conducted, and a workshop was organized for thermal-processing specialists.

The proposed "Standard practice for the establishment of thermal processes for food packaged in flexible containers" has been accepted by the Canadian Government Specifications Board (CGSB) as part of a comprehensive standard on retort pouches, and has been approved at the American Society for Testing Materials (ASTM) subcommittee level.

Technology transfer continued to play an important role in the program. Researchers from provincial governments and universities were instructed in food texture measurement techniques, and seminars/workshops were presented in Vancouver, Kemptville, and Chatham. The program for industry/laboratory projects (PILP) study on restructured steak was completed and a PILP program on Cryogran is ongoing.

A Master of Science candidate from the University of Manitoba completed his laboratory research at the centre and returned to Manitoba to write his thesis.

INSTRUMENTATION AND AUTOMATION

The program on automatic grading and inspection of agricultural products by machine vision continued. The main focus was placed on automatic egg grading. The prototype tomato grader being developed under contract advanced to the pilot model test stage at a canning plant. A "beef inspector" measuring color on a cut carcass is undergoing field evaluation and testing. A tobacco leaf thickness measuring gauge was developed, using a digital micrometer.

Several computer-based systems were built for recording and analyzing data from dough quality measuring instruments used to evaluate wheat breeders' samples (i.e., the mixograph, farinograph, and dough extensometer).

Instruments and equipment were developed for cell fusion in genetic engineering experiments; a semiautomatic wing bander for 1-day-old chicks; a soil water level recorder; a piezometer for segregation of soil water strata; a soil core sampler; and a steamer to arrest enzyme activity in alfalfa.

Advisory and technical assistance was provided to support departmental initiatives in hog grading, wheat carrier ship inspection by machine vision, and electronic identification (EID) of livestock.

STRUCTURES AND MECHANIZATION

Mechanization

Modification and testing of the prototype harvester for solid-set strawberries showed that acceptable functional performance and durability have been achieved. An associated processing, distribution, and retailing program contract completed development of equipment to mechanize the crop packing operations. The work showed that machine-harvested berries could be economically processed in a purée form that was acceptable to food manufacturers.

A second-generation, motorized soil penetrometer was developed, improving measurement speed and accuracy. Excellent progress was made in developing a once-over pickling cucumber harvester, demonstrating that this production technique has potential under Canadian conditions.

Structures

The Canada Plan Service (CPS) completed 13 plan sets in English and French and publication of 36 plans and 19 leaflets. Revisions and new plans for the swine series have been completed. A computer program from Purdue University for structures design was adapted to Canadian design standards and is now being used in the CPS design work.

Design parameters for self-adjusting slot air inlets, a new idea for barn ventilation, were experimentally verified, and in response to field engineer enthusiasm, plan 9715 giving design details was published in both metric and imperial versions.

An analog computer model to analyze and design truss joints by considering their semirigidity was validated, providing a new and more accurate design tool. Preliminary sampling of dust in naturally and mechanically ventilated hog barns did not detect any significant difference in respirable dust concentration between the two systems.

A contract to instrument and record silage pressures on a bottom-unloading concrete tower silo was completed. The data will contribute to realistic design criteria. A contract to test steel roof diaphragms for wind-bracing agricultural buildings was completed, and provided data on strengths of different cladding material profiles and fastening methods. CPS plan M-9310 was revised to take advantage of the superior performance of the special edge-purlin connection developed. A contract to compare different systems for flushing manure from partially slotted floors in pig barns was completed, and found the systems equally safe in terms of animal health and performance.

STATISTICAL RESEARCH

Biometrical support was extended to all commodity groups by designing experiments, analyzing data, maintaining and enhancing computer software, and conducting research on statistical methodologies.

Collaborative work included beef cattle production in the Northern Clay Belt of Ontario; the nutritive value of naked oats for swine; the effect of dietary electrolyte balance in swine; a comparison of urine collection devices for swine; vitamin and trace mineral uptake and metabolism in ruminants; and changes in the mineral contents of stored dairy cattle manure. A chick embryo assay was developed for detecting mycotoxins in feedstuffs.

The breeding programs for barley, wheat, potatoes, and soybeans were supported. Collaboration with the Northern Agriculture Research Group included studies on forage crops, zonation, honey production, and the cold-hardiness of leafcutting bees.

Other studies included the estimation of bioavailable energy and essential amino acids in poultry feeds. Contrary to widely held belief, many amino acid supplements were found to be not 100% bioavailable. Investigations were initiated into improving the accuracy, precision, and efficiency of the true metabolizable energy assay and into the development of a true metabolizable mineral assay. A method of statistical analysis for poultry growth experiments was developed, which obviates the need for initially slaughtered birds.

Sensory food evaluation studies included the design and analysis of taste panel experiments dealing with beef, veal, pork, lamb, turkey, cheese, eggs, and strawberries. In order to improve the precision and accuracy of taste panel experiments, research into methods of response adjustment (magnitude estimation) continued. The vitamin C content of wheat and potatoes and the formulation of chicken meat acceptable for sausages were studied.

Analysis demonstrated that increasing digestion temperature and time in the hydride generation atomic absorption spectrometry method of determining selenium levels in body fluids eliminates the serious bias observed in earlier usage of this technique.

A protocol was established for detecting outliers; this technique seems particularly useful for locating aberrant values among the predictors in model-building applications. Methods for estimating the optimum plot size and number of replications for field experiments were developed. Several criteria for assessing cultivar stability were studied and their differential properties clarified. A measure of the information gained by clustering and a test of significance for this measurement were developed; this technique can also be used to compare different groupings. A procedure for choosing the characters that provide optimal discrete discrimination was obtained.

On approximately 135 occasions statisticians advised researchers from 25 establishments throughout Canada on various matters, the areas of interest being primarily experimental design, use of computer software, and interpretation of data.

The library of computer software continues to be used about 1000 times per month. To assist researchers, an online library of examples using SRS programs, and the SAS and GENSTAT software systems has been implemented. A bulletin describing features of and changes to these systems is distributed to personnel at more than 25 research establishments. A quarterly newsletter was distributed to all branch establishments.

The computer systems and programming unit responded to 325 ad hoc requests originating throughout the branch for assistance. A fitting constants capability has been added to the SRS computer software library. Almost all computing has been transferred from a service bureau to the centre's VAX 750 minicomputer.

The biometrics support group provided training in data entry and the use of statistical software to branch personnel from the four Ottawa research establishments. SRS-developed computer programs were sent to two research stations with their own minicomputers and to four research/government establishments outside the department.

SUPPORT SERVICES

At the request of the Canadian Society of Agricultural Engineers, a complete index of Canadian agricultural engineering references from 1959 to 1986 was compiled. Many other reference publications were published, including a listing of current federal and provincial agricultural engineering publications. The data base on agricultural engineering research and development was further expanded, focusing on Canadian research. The information system contains some 26 000 entries. Work continued on making the data base accessible to external organizations via computer networks. The centre's field library was maintained to provide interlibrary loan services within the department.

TECHNICAL DEVELOPMENT AND SERVICES

Technical development machine shop

The numerically controlled machine tools acquired in recent years are now in routine use. It has been clearly demonstrated that it is cost effective to produce components, either singly or in groups, by these methods. The key advantage is that if, during development work, the component must be modified, the replacement part can be rapidly produced with minimum labor. This is improving the support provided by the workshop to all of the engineering research programs.

Maintenance services

Services are provided to Ottawa establishments to maintain scientific equipment. Constraints on resources have dictated that services be reduced. This has been accomplished by some contracting out of work and by an expanded preventative maintenance program that has definitely paid off. The annual number of work orders has thus been reduced about 50% to 1200.

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B. Zhou People's Republic of China	Pesticide residues analysis
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[1] **On transfer of work, Tanzania-Canada wheat project, Arusha, Tanzania, April 1986-April 1988.**

INTRODUCTION

The Land Resource Research Centre (LRRC) continues its responsibility for national programs in land resources and agrometeorological services. The activities of the centre include the national soil survey program; a supporting program in soil classification research; a program involving studies in land evaluation, agricultural land use, and soil degradation; and an agrometeorological program that includes agrometeorological services, farm weather service, crop-weather modeling, and crop information.

During the year a large complement of staff members working in soil chemistry, soil mineralogy, and environmental chemistry were regrouped in the centre. The program scope of the centre has been broadened to include activities in these fields of specialization.

The centre continues to respond to the sustained concerns about soil degradation, and both its research and operational activities have been increasingly oriented to the maintenance and enhancement of the quality of the agricultural land (soil and water) resources of Canada. Emphasis continues to be given to the assessment of soil quality and the state of degradation of soils.

The centre has continued its active role in the application of soil survey and agrometeorological information for agricultural regional development, conservation programs, the development of farm weather services, and similar activities involving the application of land information for development planning.

This report gives the outcome of the continuing activities of the centre during 1986. More complete information can be obtained from the Land Resource Research Centre, Research Branch, Agriculture Canada, Ottawa, Ontario K1A 0C6; Tel. (613) 995-5011.

J.S. Clark
Director

ROLES OF THE CENTRE

The activities of LRRC include research, development, and services related to Canada's land resources. These activities not only support other research within the Research Branch but also provide information essential to policy- and decision-making for regional and national levels of government, educational institutions, and agri-business. The centre, in pursuit of these activities, provides leadership and is responsible for a number of national programs related to land, including those outlined below.

Soil inventory. Soil mapping is done by LRRC staff in cooperation with provincial and university personnel throughout the nation. LRRC, through correlation, provides quality control on soil maps and reports. Maps are prepared showing the distribution of soils and land capability for various potential uses.

Canada soil information system (CanSIS). Soil survey, soil management, crop yield, and cartographic data are stored in a computerized system and are thus available to users throughout Canada.

Soil taxonomy and interpretations. Improvements are developed in taxonomic and interpretive soil classification systems through research and integration of information from many sources.

Soil degradation. Increased effort has been devoted to the assessment of the degree and extent of soil degradation in all regions of Canada. At present, maps and data are being prepared to provide general broad-scale information on soil degradation in all regions. Technology and procedures for monitoring soil degradation are also being developed.

Land evaluation. Data on soils, climate, agronomy, and economics are being integrated to develop improved methodology for predicting crop yield potential and assessing the quality of the land resources of Canada for various uses.

Agrometeorological data archive. Agrometeorological data and processing services are provided.

Crop information system and agroclimatic resources. Agroclimatic resources are assessed to provide information for efficient management of agricultural resources. Work on crop information systems has been reduced, and present activities are concentrating on maintaining familiarity with new developments.

Committees. LRRC contributes to the integration of land-related and agrometeorology activities of Agriculture Canada and other federal and provincial agencies through participation in a number of committees. These include:

- Canada Committee on Land Resource Services (CCLRS) and the associated expert committees
- Provincial agricultural services coordinating committees and soil survey committees
- Canada Committee on Ecological Land Classification
- Interdepartmental Committee on Land Use
- Interdepartmental Committee on Water
- Geotechnical Committee of the National Research Council of Canada and the Peatland Subcommittee
- Canada Advisory Committee on Remote Sensing
- Committee on Great Lakes Water Quality
- Interdepartmental Committee on Air Surveys
- Canada Expert Committee on Agrometeorology
- Atlantic Advisory Committee on Agrometeorology
- Ontario Climate Advisory Committee
- Canadian Advisory Committee on Remote Sensing and associated committees
- Comité de coordination des services agricoles du Canada (CCSAC)
- Commission d'agrométéorologie du Conseil des productions végétales du Québec (CPVQ)
- Atmospheric Environment Service (AES) Task Force on Standard and Nonstandard Climatic Data
- Canadian Committee on Climatic Fluctuations and Man
- Atlantic Forage Crops Zonation Committee (ad hoc committee of Atlantic Advisory Committee on Forage Crops)
- Interdepartmental Task Force (Crop Information System)
- Ontario Agrometeorology Research Committee
- Expert Committee on Agrometeorology, Subcommittee on Automated Data Acquisition
- Canadian Climate Program Socioeconomic Committee
- Canadian Climate Program Data and Applications Committee

PROGRESS AND ACHIEVEMENTS OF THE CENTRE

Environmental chemistry

Supercritical methanol extraction of bound pesticide residues from soil and plants. Soil and plant samples containing bound ^{14}C residues of a number of pesticides or their metabolites, or both, were extracted with supercritical methanol. In a parallel experiment they were subjected to the high-temperature distillation technique. The extracts or the distillates were purified and analyzed by gas chromatography and gas chromatography–mass spectrometry. A comparison between the results obtained with both techniques revealed that better recoveries of ^{14}C and higher concentrations of residues identified were obtained by the extraction with supercritical methanol. The work demonstrates the feasibility of supercritical fluid technique for the extraction of bound pesticide residues from soil and plants often not detectable in routine residue analysis.

Bound pesticide residues in soil and plants. The formation of bound ^{14}C residues in an organic soil treated with ^{14}C-fonofos and in onions grown in the treated soil was investigated under field conditions. A steady decrease of extractable ^{14}C residues was accompanied by a corresponding increase of bound ^{14}C residues in the soil over the 130-day growing period. Fonofos was the major constituent present in the form of bound residues in soils. Onions harvested 130 days after treatment also contained small amounts of bound ^{14}C residues in the form of fonofos oxon and trace amounts of methyl phenyl sulfone.

The release of soil-bound ^{14}C-prometryne residues was affected by soil pH, fertilizer treatments (with or without plants), and the crop species wheat (*Triticum aestivum* (L.) Merr. 'Marquis') and soybean (*Glycine max* (L.) Merr. 'Maple Presto'). More of the bound radioactivity was released following large pH changes in the soil than with small deviations. In addition, more ^{14}C-prometryne was found in the extracts of the soil incubated with large pH alterations. Fertilizing with ionic nitrogen sources (NO_3- and NH_4+) in the absence of plants was also responsible for releasing higher levels of radioactivity than with the nonionic fertilizer urea. These fertilizer-induced differences in release were not apparent when wheat plants were added to the system. Release of the bound radioactivity, however, was plant specific, particularly in the rhizoplane, since soybean roots elicited a greater release in the rhizoplane than wheat roots. Transport and metabolism of these residues were also plant specific.

^{14}C-Dieldren, ^{14}C-permethrin, and ^{14}C-carbofuran were applied in commercial formulations to radishes (*Raphanus sativus*) at 11.1 kg/ha and maintained in environmental growth chambers. Edible portions of the radishes were sampled 21 days postapplication, chopped, and exhaustively extracted with solvents. The amounts of bound ^{14}C residues formed in the dieldrin-, permethrin-, and carbofuran-treated radishes were 23.5%, 28.6%, and 92.6%, respectively, of the total plant ^{14}C. The compounds that were present in the form of bound ^{14}C residues in radishes were identified as the parent pesticide or metabolites of similar chemical structure.

Corn leaves homogenates were found to release bound ^{14}C residues from the aerial portion of matured corn plants treated with ^{14}C-atrazine. The 22 000-g pellet and 10 000-g supernatant fractions were the most active in releasing the bound ^{14}C residues. The released ^{14}C residues comprised mainly 2-OH analogues of the *N*-monodealkylated analogues of atrazine. It is suggested that the enzymatic system in plants may cause metabolic conversion of bound residues.

Bioavailability in rats of bound pesticide residues from plants. The bioavailability of bound residues from radishes treated with ^{14}C-dieldrin and ^{14}C-carbofuran was investigated by feeding the rats ^{14}C-material obtained after exhaustive solvent extraction. For comparison, nonextracted radishes were also fed to rats. The ^{14}C residues were predominantly excreted in feces. Urinary excretion of ^{14}C from rats fed nonextracted material was relatively greater than from those fed extracted radishes. The excreted material from rats fed dieldrin-treated radishes contained mainly parent compounds as residue. However, carbofuran and two of its metabolites, 3-hydroxycarbofuran and 3-ketocarbofuran, were present in feces and urine samples of rats fed carbofuran-treated radishes. These data demonstrated that bound residues in radishes treated with dieldrin and carbofuran have a low degree of bioavailability in rats. The results also show that bound residues in dieldrin-treated radishes would be more bioavailable than in the carbofuran-treated samples.

Bean plants were treated with deltamethrin labeled with ^{14}C at the methyl benzylic position. The aerial portion of the plants was exhaustively extracted with solvents, and the extracted material containing bound ^{14}C residues was fed to rats. After 4 days, 60% and 53% of the dose was excreted in feces and 31% and 20% in the urine of rats fed extracted bean plants treated with deltamethrin labeled at the methyl and benzylic position, respectively. The data demonstrated that bound residues in bean plants treated with deltamethrin may be bioavailable in rats.

Biodegradation of pesticides in soil. Soil from a field exposed to *S*-ethyl dipropylthiocarbamate (EPTC) for several years had an accelerated rate of the herbicide degradation compared to the soil from an adjacent field having no history of EPTC application. Soil enrichment techniques were used to isolate an *Arthrobacter* strain that effectively degraded the herbicide in a minimal culture medium supplemented with EPTC as the sole source of carbon and energy. The isolate was morphologically and biochemically characterized and found to contain three plasmids of various molecular weights. The loss of EPTC-degradative ability in the mutants was correlated with the loss of only one of the plasmid species in the parental strain. This plasmid was self-transmissible. It was conjugally transferred to mutants of *Arthrobacter* deficient in EPTC degradation. The acquisition of the plasmid by the mutants or by other plasmidless EPTC-deficient isolates from unexposed soil resulted in the restoration or appearance of EPTC degradative activities in the exconjugants. The plasmid associated with EPTC degradation was purified and partly characterized.

Soil chemistry

Soil organic matter and soil nitrogen. To better understand interactions of soil organic matter with mineral soil components, particle-size fractions, ranging from sand to fine clay, were separated from the surface horizon of an Orthic Humic Gleysol. Humic acids were then isolated from the soil and from each particle-size fraction. All materials were characterized by chemical, spectroscopic, and biological methods. The highest concentrations of C and N were found in the fine silt fraction. C-to-N ratios of all particle-size fractions decreased with decreasing particle size but δ15N values and proportions of mineralizable N increased. It appeared that quantities of mineralizable N were not only a function of the total N content but also of the characteristics of the minerals with which the organic matter was associated. N in sand and silt fractions was more resistant to mineralization than was N in clay fractions. More C and N were removed by dilute base from fine clays than from the whole soil or any of the other fractions. ^{13}C-nuclear magnetic resonance (NMR) spectra showed that humic acids extracted from clays were more aliphatic than humic acids extracted from larger particle sizes. The major aliphatic components in the clay size fractions appeared to be alkanoic and hydroxyalkanoic acids. The data show that interactions with minerals affect the chemistry and biodegradation of soil organic matter.

^{13}C-NMR of humic substances. Chemical and NMR studies on humic and fulvic acids were extended to include novel multipulse techniques to deduce more information from ^{13}C-NMR spectra and to better understand relaxation studies of molecular motion of humic acids in solution. ^{13}C-NMR was also applied to characterizing the degree of decomposition of organic soils, to estimating the carbohydrate content of soil organic matter, and to investigating the decomposition of forest litter. Studies were initiated on humin, an insoluble soil organic matter fraction, which has so far received little attention. A purification process was followed by chemical and ^{13}C-NMR techniques, which provided valuable insights into the chemical structure of humin and its relationship to humic and fulvic acids.

Microbial reactions in soils. Laboratory experiments done at 4°C showed that bacteria could oxidize the ferrous iron in biotite to the ferric form. The end product of this reaction was the formation of the mineral jarosite. Because both minerals (biotite and jarosite), as well as iron-oxidizing bacteria, are present in cold acid sulfite soils in Canada, the laboratory results indicate that in soils both the weathering of biotite and the synthesis of jarosite are microbiological processes.

A mixture of nitric acid and phosphoric acid at pH 2 was found not to inhibit the ability of *Scytalidium acidophilum* to produce alcohol from glucose. This finding is of interest to paper companies because they are planning to produce alcohol from nitric-phosphoric acid digests of waste wood chips.

Soil mineralogy

Reactions of polynuclear aluminum hydroxy cations with a clay. Stable polynuclear aluminum hydroxy cations were formed by the addition of OH ions to Al^{3+} when the formation of any precipitate was avoided. This was achieved by slowly neutralizing Al^{3+} with a small amount of dilute NaOH solution at a time. At the end of neutralization, approximately 70% of Al were polymers and the remainder was monomer. The average composition of the polynuclear Al hydroxy cations was $Al(OH)_{2.24}$ and was independent of the OH–Al molar ration of neutralization. The ionic activity product $(Al)(OH)^3$ in polynuclear solution was supersaturated with respect to amorphous Al precipitate, interlayered Al hydroxide, and gibbsite. When a montmorillonite was added to the solution, the montmorillonite preferably adsorbed the polynuclear cations, forming a stable complex that was, in many aspects, similar to chlorite. This gave a new insight into the transformation mechanism of montmorillonite into chlorite in soils.

Characterization of expandable soil clays and vermiculitic smectites in spodosols. Some expandable soil clays behave as typical reference smectites in their expansion behavior with Mg and glycerol saturation and as typical reference vermiculites in their contraction behavior with interlayer cations such as K, NH_4, and Rb. It was hypothesized that this behavior was related to layer charge characteristics and structural inheritance of the soil clays, and thus the expandable clays from five different kinds of soils were investigated. The results showed that the expandable clays of all these soils satisfied expansion and charge criteria for smectites and could therefore be defined as smectites.

However, the mica-derived smectites from the Spodosols con-tracted much more readily with K saturation and had a much greater fixation capacity as compared with the nonmica-derived smectites from other soils. Because the vermiculitic characteristics of soil smectites are important for agronomic purposes and in soil genesis studies, it was proposed that the criteria for identifying and defining smectites be retained but that additional measurements of K fixation and layer contraction be made to determine the vermiculitic behavior.

Mineralogical variability of clay in soils. There is an increasing need for information on soil variability, but nearly all the studies on this subject have dealt with the more easily measured and quantified soil properties, and clay mineralogical variability has been neglected. Consequently, the variability of clay mineralogical composition in a systematically sampled map delineation of Brandon soil was investigated. Although the variabilities of other properties such as organic matter content and particle-size distribution were large, the variability of clay mineralogical composition was relatively small, with coefficients of variation less than 20%. This was attributed to the uniformity of the parent marine clay and the young age of the soil. It was also demonstrated to what extent the determination of spatial variability of clay mineralogy is limited by the precision of mineral quantification methods.

Ferruginous smectites in soils developed on basic igneous rocks. In eastern Canada, especially Quebec, numerous basic igneous rock bodies are distributed widely, although their size is limited in comparison with the large areas of granitic rocks in the Canadian Shield. Soils developed on the basic igneous rocks often contain ferruginous smectites. A representative site was chosen and investigated to identify the minerals and to characterize the weathering involving mineral formation. The results showed that the mineral was a smectite that was rich in magnesium and ferric iron, had a high charge, and was more similar to saponite than nontronite. It was proposed to call this smectite ferri-saponite. Extensive weathering caused decomposition of most original mafic minerals and magnetite for form goethite, lepidocrocite, and iron-rich clay minerals including ferri-saponite, and felsic minerals were partly altered to kaolinite. The extent of weathering was strongly influenced by the microenvironment.

Corrensite found in eastern Ontario soils developed on dolomite. An interstratified clay mineral was detected in some soils in the area of Saint George Lake, near Perth, Ont. An examination showed that the mineral was not pedogenic but inherited from the underlying rock, dolomite. A nearly pure interstratified clay mineral collected from the dolomite was found to be a low-charge corrensite, which is a 1:1 regularly interstratified mineral of smectite and chlorite. Field observation and laboratory examination suggested that the corrensite was formed as an alteration product of phlogopite present in dolomite in the area.

Mineral Analyses Service. More than 30 professional and technical staff members of the Ottawa research centres, off-campus stations, outside agencies, universities, and other government departments made use of the services of mineral analyses by X-ray diffraction, infrared, Mössbauer effect, gas-adsorption, and thermogravimetric methods. The Mineral Analyses Service provided more than 3000 X-ray diffractograms, 165 X-ray powder diffraction photographs, 190 infrared spectra, and 51 Mössbauer spectra. The service also contributed supportive data to at least 18 papers and reports on mineral characterization of Canadian soils, mineral weathering, mineralogy of Alberta tar sands, soil acidification, acid sulfate soils, mineral equilibrium in soil systems, the nature of soil clay minerals, and methodology development for mineral characterization and quantification. The quality and capacity of the Mineral Analyses Service laboratory were increased by designing new analytical procedures and applying techniques known in other fields of science to mineral analysis. A special procedure was designed to prepare specimens that can be used for the analysis by both reflection-type and transmission-type diffractometers without repacking or remounting specimens for each diffractometer. This procedure considerably reduced the amount of sample required for analysis and completely eliminated unavoidable inconsistencies resulting from different sample preparations. The use of a zero-background quartz slide was found to be very effective in detecting an extremely small amount of clay minerals mounted on the slide, in comparison with microscope glass slides, which are normally used.

Analytical Chemistry Service. The Analytical Chemistry Service provided branch establishments with chemical analyses in support of research projects in a broad variety of disciplines. A wide range of agricultural research materials were analyzed for constituents such as dietary fiber, fat, lignin, ash, macroelements, minor elements, and trace elements of nutritional and toxicological relevance, nitrogen, protein, amino acids, and organic functional groups. Some 32 000 determinations were provided to professional and technical staff of 12 branch establishments. Preparation and physical characterization of a bovine muscle powder candidate reference material were completed, which after chemical characterization will be made available to agricultural and other laboratories for analytical quality control.

Soil resource inventory and mapping

Field mapping was conducted in all provinces, except Prince Edward Island, accompanied by related correlation, map compilation, and report writing. Area coverage was enhanced in Saskatchewan, Nova Scotia, and New Brunswick because of supplementary funding through Economic Regional Development Agreements (ERDA) or Agricultural Food Development Agreement (AFDA). In total, national coverage was 3.5 million ha, which ranged from very detailed studies around town sites and on prime agricultural land to reconnaissance surveys in forest reserves or exploratory surveys in northern wilderness areas. Thirteen reports were published, and 31 were submitted for publication. Continued emphasis was placed on agricultural research planning and on mapping attributes essential to the interpretation of soil conservation. Attention was also directed to mapping quality and documentation of procedures for determining map reliability.

Newfoundland. The report entitled *Soils of the Terra Nova Agricultural Development Area* was published, and technical editing was completed for the following reports: *Soils of the Bonavista Peninsula, Soils of the Gander Lake Map Area*, and *Soils of Stephenville–Port aux Basques Map Sheet.* Technical editing was also completed for reports and maps to be published in a Canada Land Inventory format: Grandy's Lake–Friars Cove, Sunnyside, and Green Bay. The generalized soil landscape map of the island of Newfoundland was completed, and testing was carried out on an agricultural capability rating system for organic soils. Some organizational work was done on the CanSIS names file.

Prince Edward Island. The unit cooperated with P. Milburn, drainage engineer at the Fredericton Research Station, and Dr. Suzuki, plant root–soil researcher, in a study on the performance efficiency of installed tube drainage systems. Hydraulic conductivity, particle size, bulk density, and root mass were measured in 10 fields to determine if after several years of observations of water-table drawdown, a simple method might be found to establish whether or not a land area can be efficiently drained.

Considerable time was allotted to active participation in several work groups and committees related to land use. Advisory services were also provided to outside agencies, including the private sector and provincial and federal departments. Editing of the Prince Edward Island report was completed by Research Program Service (RPS) and finalized for publication.

New Brunswick. Efforts continued to be directed toward the completion of backlogged soil survey reports. Editing of the Chipman–Minto–Harcourt report was completed by RPS. The Sussex area land base study was published, and a draft manuscript was prepared for the exploratory soil survey of central and northern New Brunswick. Three map sheets were surveyed in the Woodstock–Florenceville area, with reporting on a 1-year time-delay basis. Two ERDA contracts were supervised: soil evaluation and mapping for agricultural land development and management in Westmorland County, New Brunswick; and identification and characterization of dense compact subsoils. Performance-management data were collected for potatoes and alfalfa. Growing-degree temperatures were monitored in the Woodstock–Florenceville area. *A report on the Soils of New Brunswick: A first approximation* was published.

Nova Scotia. The Kentville–Sheffield report was submitted to LRRC for publication, and the Pictou County report was submitted to RPS; the Colchester County report was completed and submitted to LRRC for technical editing. Correlation continued on the AFDA soil survey contracts in the Annapolis Valley, Cobequid Shore, and Northumberland Shore regions of the province, with 29 map sheets completed.

Thirty map sheets completed in 1984–1985 were submitted to the Cartography Section for printing. The Cambridge Station and the Nappan map sheets were completed and correlated. A draft report was written on the Nova Scotia experience with survey intensity level (SIL) 2 soil survey contracts, and electronic data processing routines were developed for field and office applications. A preliminary report by the CanSIS–computer working group on the design of soil attribute files was completed.

Quebec. The final reports for Richelieu and Vercheres were completed; these reports incorporated statistically defined fertility data of surface horizons. A soil association map and report of Rouville County was compiled at a scale of 1:50 000 and distributed to selected users. Detailed mapping and field sampling were completed in Chambly County, and a reliability study was completed in Verchères County. One member of the unit participated in a working group to define the cartographic file structure of the CanSIS Animal Research Centre (ARC)–Info system. Cooperation began with ERDA on the Rimouski survey project and with Laval University on crop assessment on organic soils. Hand-held computers were tested in the field, and data were transferred directly to a data base management program at the field office. A note on a rapid method for routine particle-size analysis was submitted to the *Canadian Journal of Soil Science*.

Ontario. Several soil inventory projects were brought to completion and are awaiting printing, including the soil report and maps for the Ottawa–Carleton region and soil maps for North Bay (eight maps) and Gogama (three maps). Six preliminary soil maps were prepared for areas of active soil surveys: St. Catharines–Niagara-on-the-Lake, Port Colborne–Fort Erie in the Niagara region; Middlesex County, east and central portions; and South Dumfries and Brantford–Oakland townships in Brant County. The generalized soil landscape maps for southern and northern Ontario (phase I area) were revised, and the southern portion was submitted for printing. Soil mapping was conducted throughout approximately 94 000 ha in Middlesex County.

Progress in soil interpretations included establishing soil suitability ratings for non-tender fruit crops for the Niagara region and preparation of computer-derived interpretive maps for soil erodibility for the Haldimand–Norfolk region. With the use of soil survey and climatic data, research was conducted to develop computer-based methods for predicting site suitability for general field crops.

Program planning has proceeded for the pilot demonstration watershed subprogram and for the contract soil survey of the watersheds. Contract research studies have been supervised to completion in soil and water conservation. These include identification of pesticide source areas and inventory of soil and water conservation practices in the Upper Great Lakes basin, and evaluation of phosphorus fertilizer management practices in southwestern Ontario. Research also has been conducted to assess seasonal variability of soil erodibility.

Technical assistance was provided to cooperating agencies in the application of ARC–Info geographic information system (GIS) using soil maps and data files for forestry interpretations, in training of forestry staff and students in the use of soil survey information for forest land management, and in developing specifications for detailed soil survey of prime forest lands. Input was made to the assessment of national and provincial requirements for ARC–Info, including types and structure of data files.

Advisory services were provided to outside agencies such as the Nonpoint Source Pollution Subcommittee of the Great Lakes Water Quality Board, and the Canadian International Development Agency.

Manitoba. The resurvey of approximately 906 km at a scale of 1:20 000 and 145 km at a scale of 1:50 000 was completed for the rural municipality of South Norfolk (D76) and Elk Island–Victoria Beach (D75); portions of the rural municipality of Rhineland (D76) and Elk Island–Victoria Beach (D73); and the rural fringe around the townsites of Elkhorn (D65) and Snow Lake (D69). Also completed was upgrading of the map and data base at a scale of 1:125 000 for 792 of 1305^2 km in the Swan Lake project (R18) and 512^2 km at a scale of 1:125 000 in the rural municipality of Rockwood (R30). Approximately 70% or 2331 km^2 of 3325 km^2 at a scale of 1:125 000 (SIL3-4) in the Duck Mountain Forest Reserve was also covered.

Reports were published or are ready for publication by the Manitoba Department of Agriculture for South Riding Mountain (D35);

Sainte Anne–Labroquerie (D39 and D49); Falcon Lake–Brereton Lake (D40 revised); Quesnel–North Shore Winnipeg River (D41 revised); Souris, Wawanesa, Virden (D56); Fraserwood (D57); Meditation Lake (D61 revised); Wanipigow (D62 revised); Shellmouth Reservoir (D63); and South Assiniboine River (D64).

A series of land degradation maps at a scale 1:1 million for wind and water erosion, as well as for assessment of the degree and extent of salinization, are now available on request. Two technical papers were completed: *Nature and Extent of Cryosolic Soils in Manitoba* was presented as a poster to the Congress of the International Society of Soil Science in Hamburg; *Mineralogical Composition of Major Soil Parent Material in Manitoba* is in the process of being printed in the *Canadian Journal of Soil Science*.

Significant progress also was made in developing improved soil survey procedures for the following: irrigation suitability classification, by preparing a revised manual including a compatibility review of soil and water quality; classification of soil water regimes adopted by the Expert Committee on Soil Survey; a manual describing soil water investigation methods; and upgrading the file on soil names for the Manitoba CanSIS node.

Saskatchewan. Reports for soils of the Swift Current National Topographic Survey sheet area and for the Indian Head and Chester rural municipalities were published, and workshops were held in these rural areas to evaluate the reports. Mapping of 1.2 million ha in the Melfort and North Battleford areas was supervised and correlated, and field data were reformatted into cartographic and attribute files for each of the 18 rural municipalities covered; preliminary reports for these rural municipalities were also prepared and distributed. Criteria for rating wind erosion risk, water erosion risk, and irrigation suitability were included in the reports on rural municipalities. Manuscripts for eight other reports on rural municipalities were completed and submitted for printing. A generalized soil landscape map of northern Saskatchewan was also completed.

A research project on the genesis and classification of clay soils in Saskatchewan was completed, including the submission of three papers for publication. Assistance in interpreting soil information was provided to Forestry Branch, Prairie Farm Rehabilitation Administration (PFRA), Saskatchewan Department of Agriculture, and the University of Saskatchewan.

Alberta. A report was published describing the soil inventory database for mapping and planning (SIDMAP). At the request of Alberta Agriculture, an internal report was prepared evaluating the application of soil types as defined by the Alberta Hail and Crop Insurance Corporation for predicting land productivity. Documentation describing the proposed land capability classification for arable agriculture in Alberta was completed, tested, amended, and submitted to the Alberta Soils Advisory Committee for adoption. A report entitled *Water Erosion Potential of Soils in Alberta* was published.

An interim report and map of a portion of the Pincher inventory area was prepared, and an additional 15 townships (140 000 ha) were mapped in the summer of 1986. The Cardston report was edited, and the maps were submitted to the Cartography Section, LRRC. Mapping for Flagstaff County was completed (20 townships or 185 000 ha in 1986), and compilation of the final report was initiated.

Terms of reference to be used in contracting private firms to conduct soil surveys were prepared and tested, and a report was submitted to the Alberta Soil and Land Inventory Coordinating Committee. A poster and map showing aridity indices for Alberta were presented at the Conference on Moisture Management in Crop Production.

British Columbia. The following reports were published: No. 32, Horsefly-Keithly Creek; No. 42, Fort St. John–Dawson Creek; and No. 40, Barkerville. The following reports were submitted for publication: No. 53, Williams Lake–Alexis Creek; Mill and Woodfibre Creeks land resource inventory; Power River and land resource; and the Gulf Island report I inventory. The Gulf Islands reports II and III were submitted to RPS for editing, and reports IV and V were submitted for technical editing. Interim maps and legends were completed for all report areas of the Gulf Islands. Digitized maps for reports II and III were edited and returned to Ottawa. Report IV interim maps were finalized for distribution, and manuscripts were submitted to Ottawa for digitizing.

A paper on predicting forest soil degradation was presented and published in the proceedings of the British Columbia Soil

Science Workshop and a publication entitled *Integrating Land Resource Inventories* was presented and published in a special symposium of the 13th Congress of the International Society of Soil Science. A manual on methods of determining soil survey reliability was prepared, reviewed, and distributed for application by other provinces. Computer programs to streamline the statistical analysis of reliability data following the procedures outlined in the methods report were written, tested, and implemented. The procedures outlined in the reliability manual were applied operationally to the Gulf Islands SIL2 inventory, the data were analyzed using the programs developed, and a preliminary report was submitted. A manual entitled *Interpreting Soils Information for Forestry* was submitted for internal review.

The potential of expert systems approaches in land resource interpretation and land evaluation were evaluated by developing a prototype expert system to interpret soil data for agriculture capability.

Yukon Territories. Field mapping of 5000 ha at SIL2 was completed in the Whitehorse area, and the report was completed for the Herschel Island project. At the farm-gate level, soil testing and productivity interpretation were completed. Field extension services and seminars were also conducted at Whitehorse.

Northwest Territories. Soil temperature probes were installed at 27 sites along the Norman Wells pipeline, and the associated soils were sampled. A progress report relating to this work was prepared and submitted to Indian and Northern Affairs Canada.

Ottawa. Twelve soil survey reports and associated map legends prepared by soil surveyors were edited and made ready for publication. Project plans were reviewed for new survey areas, and regional field correlation was conducted on most active project areas.

Cartography. The section completed 35 soil maps and 3 atlases for Agriculture Canada and 15 maps for Environment Canada. Fourteen were digitized for the 1987–1988 printing schedule, and 371 miscellaneous projects were completed for the department. Forty-one new mapping projects were started for Agriculture Canada and one for Environment Canada.

A total of 115 maps were completed for CanSIS and within a total of 1556 map plots produced, 228 were interpretive plots. The map plotting service has been maintained for the Manitoba CanSIS node.

Displays were successfully produced for the Research Branch centennial celebrations, the chrysanthemum show, and the Congress of the International Society of Soil Science, Hamburg; the 1985 Outlook Conference display was erected twice in Ottawa and sent to Saskatoon for a conference.

Generalized soil landscape mapping. Maps and computerized extended legend files were completed for the agricultural region (phase 1) and submitted for publication; the map for Alberta was published. Computerized legends for maps of the Prairie Provinces, when joined to data sets of soil degradation and Canada Land Inventory maps, provided a comprehensive data base applicable to a variety of land management decisions. This integrated data base was used as the prime data source to supply PFRA with information for their discussion paper, entitled *Conservation Reserve for Marginal Land Conversion.* The data were also used to supply a joint Agriculture Canada–Environment Canada project, with information to identify key areas for monitoring pesticides in groundwater.

The methodology and soil attributes essential to the mapping of phase 2 wilderness areas were finalized and included in the procedures manual. Compilation of the phase 2 map was completed for the Lockhart River area and the Firth and Horton River area, both in the Northwest Territories, and for the southeast Yukon.

Soil classification

The Soil Classification Section undertakes research relevant to the needs of soil inventory and interpretations thereof, publishes basic information on the nature and genesis of soils, and provides field and laboratory services for all sections of LRRC. Progress is reported in relation to the projects and services.

Organic soils. Mineral and organic soils polluted by Cu and other metals near Noranda, Que., were studied in the context of using Cu for optimizing and sustaining agricultural use of organic soils. As metal content increased, microbial biomass, carbon mineralization rate constants, enzyme activities, and respiration decreased, but priming on ^{14}C-glucose additions increased. In contrast to the retention of Cu in the surface layers near

Noranda and in cultivated organic soils in Sainte-Clothilde and Ormstown, Que., part of the Cu applied to the active deltaic marsh soils of Keswick, Ont., was found to have been carried to the sublayers by partly degraded and humified organic particles as shown by ^{14}C dating, pollen analysis, and particle-size distribution.

In a study on the amelioration of mineral sublayers by admixing with organic overlays, the percentage of organic matter was found to prevail over the source of organic matter and the types of crops grown. The levels of organic matter correlated positively with available water, water retention, crop yield, and aggregate stability but not with extent of aggregation. A series of demonstration plots on improved methods of using shallow organic soils are being maintained at Sainte-Clothilde, Que.

By using a sampling system newly designed here, concentrations of gaseous and dissolved methane in various layers of two areas of peatland water were measured over a season near Ottawa. The observed presence of pressurized gaseous and dissolved methane in deeper layers of peatlands is in accord with the concept first proposed here that degassing of the methane at water-to-air interfaces helps deter drainage of peatlands.

Mineral soil. Soil data on ^{137}Cs and the universal soil loss equation (USLE) were used to estimate soil erosion of medium-textured soils along three transects (ranging from 425 to 1040 m long and from 4.8 to 6.0% slopes) in New Brunswick that had been in nearly continuous potato monoculture over the past 15 years. ^{137}Cs data indicated that the rates of soil erosion and redistribution varied widely along the transects, and that the rates were related to the landscape positions along the transect. The results of this study show that the USLE routinely overestimated soil losses on certain landscape positions. The use of ^{137}Cs data in conjunction with USLE provided the most realistic estimate for soil erosion.

As part of the effort in quality control of data for soil survey laboratories across Canada, eight Expert Committee on Soil Survey (ECSS) reference soil samples were collected and processed. The sample covered a wide range of some of the most commonly determined soil properties for soil inventory. The eight samples were also representative of all major soil horizons. About 20 laboratories participated in the analysis, the results of which will be used to evaluate data quality for the participating laboratories. The ECSS samples will also be used as marked samples in many soil laboratories for quality control of internal soil data.

Organic fractions in soil samples under various types of vegetation from the James Bay–Hudson Bay area were determined. Results showed that the B horizons of Podzolic soils had properties similar to those of other areas of Canada. Likewise, there is no significant difference between the organic matter fractions of the dark- and lighter-colored subhorizons extracted from Podzolic and podzol-like B horizons developed on calcareous gravelly beach ridge.

Five exchangeable cation methods were compared (NH_4OAc, 2 *M* NaCl, 0.1 *M* $BaCl_2$, 0.3 *M* $BaCl_2$, and 0.1 *M* $SrCl_2$). The results showed the current method of using 2 *M* NaCl is satisfactory, except when Na is an exchangeable cation. In that case 0.3 *M* $BaCl_2$ gave acceptable results.

Soil-water structure. The motivation behind this project is to show the way in which soil structure influences the water and air regime of soils and to develop improved methods for characterizing the soil structure.

Assessment of the Guelph Permeameter (GP) method for in situ measurement of field-saturated hydraulic conductivity and matric flux potential resulted in improved procedures for data collection and analysis. The results have been submitted for publication. The GP apparatus is now being marketed around the world by a company in Santa Barbara, Calif. Further development of the GP method is currently under way for measurement at the soil surface, for measurement during a nonideal flow situation, and for in situ measurement of the hydraulic conductivity–pressure head relationship.

A new analysis of the percolation test, based on three-dimensional, saturated–unsaturated flow theory, was developed and published. This analysis improves on the traditional approach in that it takes into account soil capilarity, test hold radius, and water depth. The new analysis identifies the field-saturated hydraulic conductivity and the matric flux potential, rather than the percolation rate, as the main soil hydraulic properties relevant to filter field design for on-site wastewater treatment facilities.

Performance testing of the instrument for reflectometry analysis of moisture in soils–

time-domain reflectometry (IRAMS–TDR) resulted in recommendations to the manufacturer for improvements that allow the use of the instrument to depths of 1 m. A theoretical analysis of the use of TDR for measurement of soil salinity and water content showed that measurement of soil salinity is possible, but at least two factors complicate the measurement. Multiple reflections of the TDR signals from within the soil limit the resolution for salinity measurement. In addition, there is a water content effect on the high frequency dielectric constant that appears as part of the electrical conductivity or salinity determination. These complications limit the resolution of conductivity 3–8 mS/m. Further research will be required to refine this precision.

LAND USE AND EVALUATION

The land use and evaluation program examines improved techniques for integrating and interpreting data on soil, climate, landform, agronomy, and economics to evaluate the potential for agricultural production and the hazards of degradation of land under alternative agricultural uses. Progress in each of the projects is as follows.

Land evaluation and crop production. Major emphasis was placed on assessing long-term data on climate, crop yield, and farm production, along with resource quality and soil moisture information, to provide improved measures of crop production risk for western Canada. This action was in response to the severe drought that has been experienced in that region over the past several years. The analysis was done using data compiled and stored in the land potential database integrated with data from Statistics Canada.

Climate risks associated with crop production included assessments of soil–water reserves for continuous wheat and wheat–fallow rotations. Average values for parameters such as available water-holding capacity and others were calculated using 60 years of data for selected weather stations; results were expressed in terms of various probability levels. Water deficits for spring cereal and perennial forages, and thermal resources for maturing wheat and barley were also calculated. Regression analyses were used to compress the data and to define relationships between the 50% risk value and more extreme (i.e., 10 and 90% risk) occurrences. In this way the impact of weather variation during drought or very wet years could be estimated.

A study of yield variation over time was completed for the Brown, Dark Brown, Black, Dark Gray, and Gray Luvisol soils of that region. Using data for 1961–1982 and Marquardt's algorithm, the effects of weather were separated from time trends. This produced a technology trend that indicated a steady increase in yield up to 1975 but that leveled off thereafter. No significant difference in trends was evident between the zones. The same model was used to calculate cumulative yield probabilities for each of the major soil zones. Because of the high correlation of wheat yields with those of oats and barley ($r > 0.94$), these results can also be used for those crops.

Socioeconomic characteristics of farms on the Canadian prairies were calculated from Statistics Canada census data. Results were expressed on the basis of the major soil zones and soil texture. Generally, farms in the Brown and Dark Brown zones are the largest, and they have low capitalization and operating costs per unit area, moderate financial returns, and high levels of economic efficiency. Farms in the Black zone are smaller, but with high capitalization and higher input costs, and high levels of financial returns and economic efficiency. Profitability and economic efficiency of northern farms are low.

A study of land use flexibility demonstrated that Manitoba has the highest potential for crop diversification, followed by east-central and northern Saskatchewan. The remainder of the area is restricted to a much narrower range of crop options. In terms of comparative potential flexibility, the Black soils are four times more flexible than the Brown, twice as flexible as the Dark Brown, and 20% more flexible than the Dark Gray soils. Comparing values of potential flexibility to current land use practices demonstrates that the Black Chernozemic soils are underutilized to the largest extent, followed by the Dark Gray and Dark Brown soils. The Brown soils, on the other hand, appear to be overutilized, but this must be investigated further.

Associated research in this program involved completion of a computer simulation model for spring wheat (referred to as PIXMOD) and testing of the model on soil–plant–water moisture for application in Canada. The latter demonstrated that SPAW is slightly more accurate than the versatile soil moisture budget but requires more input data.

Canada Soil Information System (CanSIS). A complete review of the existing CanSIS operations and organization has been completed. Based on the review findings, CanSIS is in the process of being updated to a distributed network of regional and national data bases.

New computer hardware and software (ARC-Info from Environmental Systems Research Institute, Canada) have been purchased and installed in Ottawa to replace the existing computerized cartographic system, which has been in production since 1974. Full implementation of the ARC-Info system and conversion of the existing data will be phased in over the next 2 years. This new geographic information system will greatly increase the ability of CanSIS to manipulate cartographic data and to prepare it for transmission to other (regional) users.

Land degradation. Estimates of the extent of land in eastern Canada and British Columbia affected by soil erosion, compaction, and acidification were completed. Associated economic analysis, using the results of this soil degradation assessment, estimated the costs to farmers in each of the 16 regions. Erosion by water appeared to be the most serious, followed closely by compaction. On-farm damage by each was estimated to exceed $100 million per year. Acidity and wind erosion were estimated to cost farmers less than one-tenth as much as water erosion and compaction.

A series of maps are being prepared to identify the risk of soil degradation by wind and water erosion based on modeling. The first maps to be published will cover the Prairie Provinces, followed by soil salinity in western Canada. Maps of eastern Canada showing risk of water erosion and acidification are also in preparation.

Results were summarized from 10 years of monitoring crop yields and soil chemical properties on and immediately adjacent to the Sarnia–Montreal oil pipeline right-of-way. Effects of soil mixing on chemical properties were still apparent despite 10 years of good crop management including high rates of fertilization. With the exception of alfalfa, field crop yields from disturbed areas were still depressed 10 years after installation.

Changes in the bulk density and water desorption characteristics of a corn-cropped humic gleysol in the Ottawa area were evaluated under a range of manure application methods including plowed under in the autumn, disked in the spring, and sidedressed with and without injection. Changes in the soil structure from the manure disposal practices varied from year to year, probably depending on the moisture state of the soils at application time. Moldboard plowing of manure in the autumn appeared to have no effect on soil porosity the following season, whereas spring treatment of wet soil resulted in compaction.

Technical assistance on soil conservation was provided on a continuing basis to the National Action Committee on Soil Conservation of the Canadian Federation of Agriculture and to the Communications Branch, Agriculture Canada. This included up-to-date reports on current activities in soil conservation, as well as programs, policies, and legislation on conservation. A list of reference materials and resource personnel on conservation was prepared, as well as media kits and general informtion for radio spots.

Agrometeorology

Weather and climate are a basic physical resource upon which agricultural production systems in Canada are heavily dependent. Research and development in the Agrometeorology Section focus on the interactions between weather–climate and crop growth and yield, pest and disease activity, and a variety of farm management decisions. Year-to-year variability in crop yield and quality, total production, pest infestation, and outbreaks of disease are very much affected by and often are to some degree predictable from weather conditions. Forecasts of crop growth, development, yield, and quality are important in marketing decisions, particularly for international export markets of major commodities such as wheat. Canadian farming needs to achieve maximum possible efficiency to remain economically competitive in international markets. Information on climatic resources assists in determining the suitability of specific crop cultivars for production and in developing the most appropriate crop and soil management practices in each region to help achieve this efficiency. Part of the goal of agrometeorological research is also to study the efficiency of biomass production and water use over large areas through highly specialized measurement techniques. Basic research on the response of crops to environmental factors continues to be essential for the development of improved models that accurately predict crop growth, maturity, quality, and yield from weather–climate data. Analyses of both real-time weather and historical climatic data facilitate the evaluation of derived indices, which are of potential usefulness to farm managers, agri-business, crop insurance programs, government subsidy programs, and soil conservation efforts.

Environment crop assessment. A data acquisition system is being developed to measure CO_2 and water-vapor flux densities for assessing biomass growth and evapotranspiration over large areas. Measurements are processed in real time to provide results on a 2, 10, 30, and 60-min basis. Measurements with this system were compared with measurements from a similar system when flying at 25 and 50 m above large uniform fields of a cereal crop near Winnipeg. A high degree of reproducibility of results was obtained. The study was part of an international experiment to evaluate flux measuring systems developed by Canada, the United States, and Japan. Six research establishments in Canada, three from Japan, and two from the United States participated in the comparison of flux measuring techniques. The feasibility of using airborne CO_2 flux measurements to provide an image of the rate of biomass production was also examined.

Detailed analyses of Landsat data were carried out at the Carberry, Man., test site using thematic mapper imagery of six bands. The use of the two extra bands (0.45μ and 10.6 μm), combined with the 30-m resolution area, improved the capability to correctly classify the variety of special crops as compared with the standard Landsat MSS data for the same region. This increased ability to classify the crops was evident in separating the seeded peas, flax, and potatoes where the amount of vegetation covering the ground surface was minimal. The high accuracy of 87% for 1 July data decreased substantially to 74% with 1 August data. Using daily meteorological data from 76 observation stations in the Prairie Provinces, production of cereals was estimated on cereals seeded on fallow and on stubble land. Estimates of production in July, based on seeded hectarage provided by Statistics Canada and yields derived from meteorological data, were close to production estimates published in December. Estimates made in July 1985 and 1986 were 819 million and 1110 million bushels as compared with Statistics Canada published production of 843 and 1120 million bushels, respectively. Studies on improving snowmelt for assessing spring soil moisture conditions are continuing.

Operations management. The Agrometeorology Section is actively involved in research to develop and demonstrate the usefulness of indices and parameters that integrate weather and soil conditions into decision-making aids for agricultural production. As part of this project, current weather conditions and derived soil moisture were monitored on a weekly and monthly basis during the year for the Prairie Provinces. Current computerized data on weather for Ontario and the Prairie Provinces were updated on a weekly basis for use by regional agricultural researchers for near real-time weather-based estimates of insect populations, disease development, and crop maturity. Preliminary work was completed on a comprehensive soil moisture monitoring and drought alert system. A system to acquire, via computer, real-time climatic data from the data banks of Alberta and Saskatchewan was implemented.

An evaluation of a soil moisture budget on data from Quebec for a range of soils and crops for 1984–1986 was completed. The model is now ready for near real-time monitoring of soil moisture in Quebec. A user-friendly version of the soil moisture budget, which incorporates a water table, was implemented on a microcomputer for farm use. It was tested for irrigation scheduling for potatoes. Work was continued on the evaluation of irrigation scheduling on horticultural crops, and a scientific publication on the response of strawberries to irrigation scheduling is in press. A study to monitor derived soil moisture on a weekly basis for two soil textures was continuing for Smithfield, Ont., in controlled-droplet application (CDA) relative to orchard crop management. Areal estimates of evapotranspiration in Quebec were compared to measurements of water vapor flux using an aircraft, and a scientific paper was written reporting the results.

A growth chamber experiment to monitor soil moisture in cylinders kept at two temperatures as they dry down from saturation was completed. Data analysis has begun to determine if this is a practical technique for estimating soil hydraulic conductivity.

Field testing of the new, low-cost leaf wetness sensor was continued. The tests suggest that this sensor could be useful in monitoring leaf-wetting duration for predicting development and control of disease for fruit and vegetable production. The sonic snow depth sensor developed here was field tested. It performed better than a commercial unit obtained for comparison purposes. A new data-logging system based on the CR21X and the IBM-PC was implemented for automatic recording and retrieval of data from the Ottawa Agriculture Canada weather site. Radio telemetry was found to provide a good alternative to the use of telephone lines for automatic data retrieval. A paper was written reporting the results. Additional testing of the electrical frost probe was carried out and the results reported.

Development and testing of an apple yield model continued. A new function to account for the effect of late spring frost on yield was incorporated. Work was initiated to acquire a comprehensive data base on weather and apple yield.

A climate analysis of hay-drying weather for seven locations in Quebec was carried out. The results were presented in a paper at a Conseil des productions végétales du Québec symposium on forages.

Agroclimatic resource assessment. Research efforts were continued toward achieving a better understanding of the relationships between plant physiological processes and crop growth and development under varying environmental conditions. A second year of a field experiment investigating photosynthetic response to irradiance of eight maize varieties with various heat unit requirements and growth strategies was completed. Mathematical expressions were derived that describe the changes in photosynthetic response of these eight varieties during development. An algorithm was also developed to estimate maize leaf area from readily available climatic variables (maximum and minimum air temperature and precipitation). This algorithm will form a component of a photosynthesis-based production model. Analysis of barley phenological data resulted in development of an algorithm to describe barley phenology as a function of temperature and photoperiod. This algorithm was used to evaluate the timing of a stress period and to determine that the effect of water stress on development rate was modified by photoperiod, i.e., the shorter the photoperiod the greater the delay caused by stress. Work is also continuing on validating a nitrogen balance model for a wheat-protein yield model.

Estimates of monthly mean soil temperatures in the Atlantic region using a regression-based model were improved significantly for winter months by including predictor variables related to snow depth in the model. Historical data on daily snow depth are being archived, in cooperation with Environment Canada's Atmospheric Environmental Service, for all available climate stations that have recorded this parameter. These data will be used along with other standard climatic records as input into the model to determine temporal and spatial variability in monthly average soil temperatures during winter in the Atlantic region for assessing overwintering conditions for crops.

Procedures for sampling and analyzing soil temperatures for soil climate classification were evaluated. Results showed that with a sampling frequency of 14 measurements per year, 3 years of data were sufficient to produce reasonably accurate estimates of soil climate parameters used in classification for the 20- and 50-cm depths under grass cover. A Fourier series model with a second harmonic (four variables) provided an improved fit to the seasonal soil temperature curve compared with a two-variable model or present sine-curve-fitting procedures used in CanSIS.

A study of seeding dates for winter wheat has shown that the average optimum seeding date was highly correlated ($r = 0.998$) with average air temperature during autumn in various regions of Canada. This relationship was used to prepare a zonation map displaying estimates of the optimum seeding period for winter wheat in the Vernon–Armstrong region of British Columbia. A similar map for southern Ontario is being reviewed by the Ontario Cereal Crop Production Subcommittee.

Procedures were developed to estimate average dates of last spring and first autumn frost in Ontario from climatic normals data. These were used to prepare estimates of frost dates for climate stations with inadequate length of record. Methods of estimating freeze dates for various critical temperatures and probability levels from the average spring and autumn frost dates (0°C) were also determined. Results are being used to prepare concise freeze risk information for use in management decisions by Ontario growers.

The presence of Stewart's bacterial disease in corn can affect marketing opportunities for seed trade with other countries. In cooperation with the Food Production and Inspection Branch, a climatic index was computed to help assess the risk of outbreaks of this disease in all regions of southern Ontario. Index values suggested that even in areas of southern Ontario where the disease is most probably found, the probability of severe outbreaks is relatively low (about 5% probability, or 1 year in 20).

Research continued on improving estimation of soil water content using a diffusion-based soil water model. Two different root water uptake functions were incorporated into the model. From comparisons between measured and estimated water use, it appeared that the assumptions involved in using only root depth gave a better correspondence than when root densities were used. Soil water content simulations were within 10% of the measured value.

Assistance was provided to the agroclimatological research project, funded by the Canadian International Development Agency, for Parana state in Brazil. Five Brazilian scientists have received training from the Agrometeorology Section, which will help them evaluate and apply agrometeorological methods and computer software used in Canada to agricultural problems in Brazil. Equipment worth approximately $200 000 has been provided to Brazil under this project, including one microcomputer system.

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INTRODUCTION

The Plant Research Centre (PRC) was established on 1 April 1986 by amalgamating the Ottawa Research Station (ORS) and the Chemistry and Biology Research Institute (CBRI). The mandate includes the development of effective technologies for crop improvement and plant health through innovative and multidisciplinary research with emphasis on biotechnology as well as the development and release of superior cultivars in selected crop species of regional and national interest.

The research and development activities involve a balanced mix of basic or knowledge-creating research (57%), applied or problem-related research (27%), and developmental or knowledge-utilizing research (6%). PRC is responding to the National Agricultural Strategy Challenges and Departmental Priorities with respect to enhanced efforts in technology development and transfer. Close collaboration is maintained with other federal and provincial organizations, universities, and private industry. This is achieved through a number of informal cooperative research arrangements and formal research partnership agreements.

PRC maintains strong breeding programs on corn, soybeans, oats, wheat, barley, alfalfa, and forage grasses. It also has substantial programs in biotechnology with emphasis on the development and exploitation of new technologies in tissue culture, molecular biology, and cell genetics. The objectives of these programs are to provide new and improved tools for the development of new cultivars and germ plasm with improved resistance to biotic and abiotic stresses, as well as more effective *Rhizobium* strains, to reduce the cost of crop production, and to recommend safer and more effective methods of crop protection.

PRC also houses the central office for the Plant Gene Resources of Canada, which is responsible for the preservation and exchange of genetics resources. The Electron Microscope Unit continues to provide services and improve methodologies in response to the needs of the centre and other departmental establishments. PRC is also responsible for the management of the entire Central Experimental Farm including the campus, the arboretum, and the ornamental gardens and provides numerous services such as the indoor growth facilities, the Research Branch vehicle fleet, and the campus security. A feature of the PRC research program is the continuous inflow of new ideas and expertise from universities and other research laboratories through exchange of scientists currently involving 3 scientists on contract, 12 visiting scientists, 14 Natural Sciences and Engineering Research Council (NSERC) fellows, and 14 graduate students.

This report summarizes only some of the more important research results from the centre in 1986. Further information can be obtained from the publications listed at the end of this report. Reprints of the research publications and copies of this report are available on request from the Plant Research Centre, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6; Tel. (613) 995-3700.

A.I. de la Roche
Director

GENETIC ENGINEERING

Developmental plant physiology

A petiole explant culture system that consistently yielded high frequencies of somatic embryos was developed for alfalfa (*Medicago sativa* L.). The capability to undergo embryogenesis was genotype-dependent but occurred rapidly in responsive genotypes with differentiated embryos visible after 15 days of culture. An efficient protocol for isolation and culture of leaf mesophyll protoplasts was established for *M. sativa* and *M. falcata* L. In some genotypes such as the cultivar Rangelander, direct embryogenesis was achieved in up to 0.4% of the original protoplast population by the 5th week of culture. In other genotypes an intermediate callus phase preceded the induction of embryogenesis. A high degree of protoplast clumping during the early stages of culture was correlated with the direct embryogenesis pathway. The application of low voltage electric currents during the early stages of culture stimulated clumping and increased the consistency but not frequency of direct embryogenesis. Embryogenesis and plant regeneration was achieved in immature inflorescence explant cultures of *Bromus inermis* Leyss. Seven donor plants that had a 70–100% response for culture initiation were identified.

Experimental haploidy

Genotypes of *Brassica juncea* (L.) Czern and *B. nigra* (L.) Koch that yielded high frequencies of haploid embryos from cultured anthers were identified. Frequencies of embryogenesis of more than 10% were obtained in isolated *B. napus* L. pollen cultures through media manipulation and density gradient fractionation. Experiments involving intranuclear microinjection of isolated pollen were initiated. As part of a collaborative program, more than 20 000 pollen-derived embryos of *B. napus* were sent for evaluation in the canola breeding program at the research station in Saskatoon.

Somatic cell genetics

Biochemical analyses of a *B. nigra* variant line insensitive to inhibitory concentrations of the amino acid analogue 5-methytryptophan (5MT) were undertaken. Expected changes in the activity of the key regulatory enzyme, anthranilate synthase were not observed; however, 2–3-fold increases in intracellular concentrations of glutamine and related amino acids were detected in the variant. Isolated pollen cultures of *B. napus* cultivar Topas were mutagenized and developing embryo populations were subsequently screened for resistance to inhibitory levels of the Dupont herbicide, chlorsulfuron. One embryo with potential herbicide resistance was selected and transferred to regeneration medium. As part of a collaborative research agreement with Hoechst Canada Inc., mutagenesis experiments with isolated pollen and haploid protoplast cultures were initiated in order to develop methodology for selecting lines with resistance to the Hoechst herbicide, glufosinate ammonium.

Methodology was established for isolating protoplasts from cortical stem tissue of *B. juncea* cultivar Domo. Plants were regenerated in 1–5% of the protoplast-derived colonies and preliminary cytological evaluation revealed the presence of aneuploids, diploids, and polyploids in the regenerant population. Plants were regenerated from several protoplast-derived colonies selected in somatic hybridization experiments between *B. napus* and *Diplotaxis harra* (Forsk) Boiss. Morphological and isozyme analyses have provided confirmatory evidence that the regenerants were true somatic hybrids. A project was undertaken to produce somatic hybrids between *B. napus* and several wild, cold-tolerant cruciferous species including fixweed, shepherd's purse, and stinkweed.

Transformation of *Nicotiana tabacum* L. and *N. debneyi* Domin., with bacterial antibiotic resistance genes was achieved through cocultivation with *Agrobacterium tumefaciens* Townsend. Transformed plants are being used as the source of protoplasts in somatic hybridization experiments between these species.

A project involving the evaluation of intracytoplasmic microinjection of *B. napus* protoplasts as an efficient method of transferring mitochondria was initiated. Procedures for obtaining sterile preparations of viable mitochondria were established and staining techniques were developed to locate foreign mitochondria in recipient cells.

Plant molecular genetics

Technology was developed for the intranuclear microinjection of *B. napus* cultivar Jet Neuf protoplasts. Based on the expression of the nopaline synthase gene as a biochemical marker, transformation frequencies of 40–60% were achieved. Transformed callus lines were established with a number of chimeric genes coding for resistance to a variety of antibiotics and the herbicide chlorsulfuron. Southern blot analyses confirmed the integration of the genes and revealed minimal reorganization of the transforming DNA. Shoots were recovered from a small number of these lines. Disarmed Ti plasmid vectors were used to transfer the antibiotic resistance genes from *A. tumefaciens* into *B. napus* stem epidermal explants. Several fertile transgenic plants were recovered and studies on the transmission of the alien genes have been initiated.

CYTOGENETICS

Cereal cytogenetics

Several additional combinations of intergeneric hybrids with crop plant species *Triticum* (L.), *Hordeum* (L.), and ×*Triticosecale* (Wittmack) have been produced. Two of the most winter hardy and salt tolerant species of *Agropyron*, *A. scirpeum* (K. Presl.) and *A. junceum* (Simonet), were crossed onto wheat and hybrids obtained at frequencies of 1.61 and 0.84% of pollinated florets, respectively. The F_1 hybrid plants were vegetatively extremely vigorous and robust, intermediate to the parents in morphology but totally sterile. Meiotic analysis indicated no chromosomal homology between parental genomes. The hybrids will be backcrossed to wheat in an effort to establish chromosome additional lines and eventually to transfer the disease resistance.

Three strains of *A. intermedium* ssp. *trichophorum* (Link) Richt., cultivars Greenleaf, Clarke, and accession No. 1210 were successfully crossed onto ×*Triticosecale* cv. Welsh. Hybrids were obtained at frequencies of 1.6% to 2.6% of pollinated florets, i.e., it is relatively less difficult to cross these species to triticale than it is to wheat. The hybrids thus are trigeneric combining the genomes of wheat, rye, and *Agropyron* and as such offer the potential of combining the best traits from the donor genomes. The hybrid plants were intermediate in morphology to the parents, extremely robust vegetatively but completely sterile. The frequency of bivalents at meiosis in the three hybrids was 4.97, 5.64, and 6.94, respectively, indicating no homology between parental genomes. The hybrids will be backcrossed to wheat in an effort to transfer useful alien variability.

Chromosome banding

The bivalent frequency in three F_1 hybrids ($2n = 14$) of *Hordeum bogdanii* Wil. × *H. californicum* (syn. *H. brachyantherum* Nevski) ranged from 0.78 to 1.76. A low frequency of trivalents was also found. In the amphiploids ($2n = 28$) chromosome pairing was characterized by a high frequency of bivalents (13.42 with 11.21 as rings). Giemsa analysis showed that the bivalents in the F_1 were formed between *H. bogdanii* and *H. californicum* chromosomes but in the amphiploid pairing was preferential. These species contain differentiated forms of the H genome and genes which suppress homoeologous pairing were present in these accessions.

Tissue culture cytology

Immature embryos of Welsh triticale (×*Triticosecale* Wittmack) and Chinese Spring wheat were callused and regenerated under regimes where the callus was either not divided or divided when subcultured. The number of plants regenerated under the former regime was approximately 5 and 2, and under the latter 18 and 3 for Welsh and Chinese Spring, respectively. When the callus was not divided no aneuploids were obtained. When the callus was divided significantly more plants were obtained from Welsh and 34% were aneuploid. The frequency of plants obtained and of aneuploids did not change for Chinese Spring.

Bromus cytogenetics

A diploid ($2n = 14$) species resembling *Bromus inermis* Leyss., was found among collections from the USSR. Hybrids were obtained with the species *B. variegatus* Bieb. ($2n = 14$). Chromosome pairing was only slightly reduced from the parental species and evidence for one interchange was found. However, the hybrid was sterile, indicating genic sterility or some underlying structural differentiation not evident from pairing.

Anther culture

As a prelude to attempts to culture isolated microspores of *Triticum aestivum* L., anther culture procedures were used to identify responding genotypes and to determine donor plant growth conditions, anther culture treatments, and media requirements. Anther callus/embryo production was obtained in Marquis, and in the winter cultivars Norstar, Fredrick, Kharkov, Fondulea, Houser, Valor, Borden, and Lennox. Plant regeneration was obtained in culture and haploid plants established in the greenhouse. Norstar and Marquis were the two most responsive cultivars. Liquid culture was superior to agar. In vitro gynogenesis of *Guizotica abyssinica* Cass to obtain doubled haploid plants has resulted in direct embryo formation from prefertilization ovules. Ovule-derived plants were also obtained via callus formation and organogenesis. These plants have been established in the greenhouse. Plants regenerated from long-term callus cultures of somatic tissue showed considerable morphological diversity and are a potential source of somaclonal variants. Anther culture procedures designed to provide doubled haploid plants of *Sesame indicum* L., have induced callus production by dehisced anthers. Plant regeneration studies are in progress.

STRESS PHYSIOLOGY

Biotechnology

A microspore derived embryogenic cell suspension culture of *Brassica napus* cv. Jet Neuf (winter rape) that could be hardened to an LT50 of −20°C by abscisic acid (ABA) at 25°C was used to study the appearance of unique genetic messages during the induction of freezing tolerance. Comparisons of in vitro translations in a rabbit reticulocyte system of poly A^+ mRNA isolated from freezing-sensitive and freezing-tolerant cells showed that a message coding for a 20 kD polypeptide appeared during hardening. The appearance of this polypeptide was under transcriptional control and was not a post-translational product. Further work indicated that this polypeptide was membrane associated, and was located in a fraction identified by Mg^{++} shift experiments to be enriched in endoplasmic reticulum.

A callus culture in liquid media has been established from anthers (microspores) of the winter wheat Norstar. Attempts to obtain a viable, rapidly growing cell suspension culture from this callus has so far been unsuccessful.

Isolated cells of cold-hardened winter wheat were more damaged by CO_2 than by anoxia at −1°C, the temperature of ice encasement. CO_2 increased amino acid and ion efflux, and reduced total energy levels (ATP, ADP, and AMP), but it did not change the ratio between these adenylates. Calcium protected against the effects of CO_2, N_2, and ice encasement at −1°C but had little effect against freezing stress. ATPase activity of partially purified plasma membrane preparations from cold-hardened winter wheat decreased markedly during ice encasement, and the ATPase activity of membrane preparations from noniced tissue was similarly inhibited by low concentrations of sodium bicarbonate. This indicated that CO_2 was associated with the earliest lesion in cellular activity due to ice encasement stress.

Winter wheat plants survived ice encasement better in the light than in the dark, and this was preceded early in the ice period by slightly higher levels of total adenylates and energy charge in crown tissues in the light than in the dark. In light, photosynthetic oxygen was evolved from leaves at −1°C in simulated ice conditions but was not evolved from crown tissue that had no chloroplasts, nor from leaves that had become anoxic.

Procedures and approaches for investigating the mechanism of low temperature injury in plants, using a tissue culture system, were developed with cucumber protoplasts. The level of chilling damage to freshly isolated protoplasts could be manipulated readily by altering culture and chilling conditions, and the changes induced correlated closely with the responses of intact plants. Alterations in chilling sensitivity appeared to be associated with changes in lipid metabolism.

Field trials and screening

The winter of 1985–1986 in eastern Ontario was marked by rains in January followed by low temperatures, which produced patchy survival of winter cereals, with plot survival of adapted cultivars at Ottawa varying from 50 to 95%. A number of soft white winter wheats recommended for Ontario gave highest survival and coldhardiness rates after September plantings (12, 13 Sept.). Late planting (10 Oct.) gave the highest survival (60%) under an artificial ice cover, for the third consecutive year. This ice cover reduced survival of 80 winter cereal lines planted in mid-September to between 3 and 20%. Some of the survivors are being carried forward for further analysis and selection.

Although damage to overwintering alfalfa by ice has been observed frequently in eastern Canada, no breeding program to select directly for resistance to this stress is in progress. The high cost of controlled environment chambers has precluded intensive selection on a large scale. A study in progress in collaboration with the Sainte-Foy Research Station indicates that there is wide variability among cultivars recommended for the province of Quebec in tolerance to ice stress. Procedures involving controlled icing in a plastic house have reduced selection costs by at least a factor of 10 compared to similar methods used in low temperature growth chambers.

As the initiation of a program to identify elite lines of corn that will germinate and grow well at low temperatures, a study of low temperature germination of seven diverse corn lines has been completed. Relatively little selection has been made for these traits among current commercial materials, and wide interline variation was observed in the following parameters: days to root germination, days to coleoptile germination, and ability to establish vigorous seedlings at a threshold low temperature. Analysis and selection will continue on commercial lines from North America and Europe, and on material from Central and South American sources.

Diseases

Typhula phacorrhiza was isolated from diseased winter wheat plants in commercial fields in Ontario. The fungus is widespread in an area designated as the snow mold region. In the field, *T. phacorrhiza* is a prolific sclerotia-producing pathogen which is a persistent inoculum source for infection of subsequent crops. In field and laboratory tests *P. phacorrhiza* was as pathogenic on winter wheat as *T. incarnata* and *T. ishikariensis* var. *ishikariensis*. These three pathogens incite terminal diseases in which the period from initial infection to necrosis is a few weeks. *T. phacorrhiza* is similar to *T. ishikariensis* var. *ishikariensis* in that it incites disease late in the winter, during March–April, whereas *T. inarnata* is active early in the winter, in January and February. *T. phacorrhiza* has been isolated from the same range of winter crops that are infected by other pathogens inciting snow molds in Ontario: wheat, barley, rye, and triticale, and also from winter rape.

Barley yellow dwarf virus (BYDV) infection is known to reduce coldhardiness of winter cereals, and in an attempt to relate the two components physiologically, a number of aspects of cellular function at low temperature have been determined. Infection in cold hardened winter wheat crowns was associated with a 15% decrease in total carbohydrate but a 35% decrease in the fructosan content, in comparison with healthy tissue. In leaves, infection resulted in a 30% increase in carbohydrate but a 4-fold increase in fructosan. Cell permeability as determined by amino acid efflux, and the active uptake of ^{86}rubidium (an analog of potassium) were both substantially increased by the virus infection. Energy status of the plants as measured by total adenylates and adenylate energy charge was not changed by infection. These changes do not yet explain the reduction in coldhardiness induced by BYDV, but they indicate that a wide range of cellular response is influenced by the virus.

MYCOTOXINS

A western Canadian strain of *Fusarium sporotrichioides* was grown in two different fermentation media, MYRO and Moss-Franks, and gave similar yields of the major metabolite T-2. Sixteen minor metabolites were detected, including three T-2 analogs (propionyl, isobutryl, and butryl) that were characterized by chemical synthesis. The hypothesis that the C-8 side chain of T-2 is derived from leucine was substantiated by ^{13}C-NMR analysis, using ^{13}C labeled leucine as a precursor. The 3'-OH T-2 was also characterized as a minor metabolite. Knowledge of the toxigenic potential of this isolate is important in view of the possibility of contamination of western grains by this species.

The toxigenic potential of 25 *Fusarium* isolates, including *F. crookwellense*, *F. culmorum*, *F. equiseti*, *F. semitectum*, *F. sambucinum*, *F. avenaceum*, and *F. graminearum* obtained from New Zealand pasture grasses and which occur in Canada, was assessed in two liquid cultures (MYRO and GYEP) and on rice. *F. crookwellense* showed the greatest proclivity for toxin production in MYRO medium, producing zearalenone, zearalenol, butenolide, and various trichothecenes. The major trichothecene was 4,15-diacetylnivalenol, together with appreciable amounts of 7- and 8-hydroxyisotrichodermin. In addition, two new metabolites, the 7,8-dihydroxy- and the 8-keto-derivatives of isotrichodermin were isolated in trace amounts. This work is associated with the possible impact of *Fusarium* species in pasture grass on the health of livestock and their fertility. This is the first detailed study of pasture fusaria and toxins from *F. crookwellense*.

Increased oxygen tension during the fermentation of *F. culmorum* enhanced the yield of butenolide and decreased that of 3-acetyldeoxynivalenol (ADON). The time of addition of the ^{13}C-labeled acetate governed whether the label enriched butenolide or 3-acetyl deoxynivalenol (ADON). Butenolide was shown to be derived via the amino acid pathway by incorporation of the ^{13}C label from ^{13}C-glutamate precursor. Tissues of 25 wheat cultivars were exposed to various concentrations of the secondary metabolites, butenolide, culmorin, and sambucinol and the trichothecenes, deoxynivalenol (DON), ADON, and 7,8-dihydroxy calonectrin and a further 30 wheat and 20 triticale cultivars studied with DON alone. Those cultivars very resistant to *Fusarium* head blight (FHB) tolerated concentrations of the toxins as much as a 1000× more than the susceptible types. The high tolerance of DON by certain resistant varieties may be due to a modified peptidyl transferase, a mutation known to occur in resistant yeasts and some plants. This in-vitro assay was field tested with 25 cultivars and the disease resistance and ergosterol-to-DON ratio determined. These field data showed that the in-vitro assay could provide a rapid and facile procedure for screening plant hybrids prior to field testing.

Kinetics of the reaction of DON with sodium bisulfite have been established. Addition of bisulfite occurred across the C_9–C_{10} double-bond rather than at the keto moiety. The DON/bisulfite adduct is much less toxic to pigs than DON, and treatment of DON-contaminated corn was shown to effectively eliminate the toxicity of the feed to pigs.

The high-performance liquid chromatography procedure for the simultaneous analysis of DON and nivalenol in cereals and animal feed was given to Paracel Laboratories, Ottawa as part of technical transfer. Analytical methodology for *Fusarium* secondary metabolites utilizing a gas chromatographic–mass spectroscopic ion trap detection was developed for underivatized and derivatized analyte. Trapping the volatile secondary products of *Trichoderma* species with known biological control properties yielded over 40 compounds, comprising both aliphatic and aromatic alcohols, hydrocarbons to ketones. A new method, gas chromatographic–mass spectroscopic isotope ratio analysis, was developed for estimating the uptake of ^{13}C-labeled precursors in biosynthetic studies, which compliment ^{13}C NMR data. Analysis of the crude fungal extract of *F. sporotrichioides* treated with ^{13}C-labeled leucine confirmed the ^{13}C incorporation into T-2 but not neosolaniol, i.e., in the C-8 side chain.

Members of the group have been heavily involved in interdepartmental and international projects. In collaboration with Consumer and Corporate Affairs, air and dust samples were collected and screened for fungi by plating and the volatile fungal metabolites analyzed by gas chromatography–mass spectroscopy. This work was the basis for an interdepartmental report on the urea formaldehyde foam insulation problem and indoor air quality.

PLANT PATHOLOGY

Mycoplasma diseases

The efficiency with which *Paraphlepsius irroratus* transmitted clover phyllody mycoplasma (CPM) was found to be dependent on both feeding time and plant species. For example, an inoculation access feed (IAF) of 1 h was enough to infect 19% of the *Matricaria maritima* plants and over 80% became infected after 72 h of IAF. With China aster, however, only 13% infection occurred even after 216 h of IAF. Forty-three plant species in 18 families were tested for their susceptibility to CPM. Twelve species developed disease symptoms and of these, eight are recorded as new host species. Some perennial species such as *Tragopogon pratensis* required cold treatment of inoculated plants before symptoms appeared, thus indicating its potential as an overwintering host of CPM.

The effects of two light intensities, three day-lengths and two temperatures on infection of plants with peach X-mycoplasma (PXM) was investigated. None of these factors affected the number of plants that became infected but temperature did influence the incubation period of PXM in plants. The symptom expression time was reduced from 36 days at 20°C to 28 days at 25°C. Immunological studies showed that mycoplasma cells can be reliably detected by immunosorbent electron microscopy (ISEM) in the extracts of individual vector leafhoppers *Macrosteles fascifrons* and *P. irroratus* after they had been fed on plants infected with aster yellows mycoplasma (AYM) and PXM, respectively. Experiments on the incubation period of the two mycoplasmas in their respective vector leafhoppers showed that they could be detected earlier by ISEM than by transmission tests. Most of the infected leafhoppers in an exposed population could be scored positive by ISEM after 7 days of AYM incubation but to obtain such information by transmission assay would require about 40 days. With PXM, the maximum number of vector leafhoppers were scored positive by ISEM after 21 days of incubation. To obtain similar information by transmission tests would need about 70 days. Heterologous ISEM tests in leafhoppers suggested that the two mycoplasmas can be distinguished from each other serologically.

Virus diseases

A virus disease characterized by mosaic and stunting in sweet clovers was observed in parts of Ontario. The causal agent of the disease was tentatively designated as subterranean clover mottle virus based on its spherical shape, 28 nm size, and a strong serological reaction with an antiserum against the virus obtained from Australia. The virus is not known to occur outside of Australia.

Further studies on the interactions of viroid-like (VL) RNA of lucerne transient streak virus (LTSV) with southern bean mosaic virus (SBMV) showed that replication of the VL-RNA does not occur under the direction of SBMV RNA in *Glycine max* (soybean), which is a host of SBMV but not of LTSV. These and earlier results suggest that the VL-RNA replicates and is encapsidated under the direction of SBMV genome in *Trigonella foenum-grecum* and *Trifolium incarnatum*, both hosts of SBMV as well as of LTSV, but not in *Phaseolus vulgaris* and *G. max*, both of which are not susceptible to LTSV. Evidence was obtained that interaction of the LTSV VL-RNA with turnip rosette virus (TRosV), another sobemovirus, is also host plant specific. However, unlike the SBMV interaction, none of the cruciferous plant species supporting the replication of VL-RNA under the direction of TRosV genome are hosts of LTSV.

SYMBIOTIC NITROGEN FIXATION

Ecology

Studies were conducted to determine the effect of variation within and between legume species of the *Medicago* cross-inoculation group on the composition of indigenous populations of *Rhizobium meliloti* in nodules of *Melilotus alba*, *Medicago lupulina*, and *Medicago sativa* grown on three soils, each with a history of one of these hosts. Characterization of *R. meliloti* on the basis of phage sensitivity revealed wide diversity of phage types (PTs) from each soil. The distribution of PTs differed markedly between soils ($P < 0.0001$) and legume species grown on each soil ($P < 0.01$). Individual plants within species were heterogeneous with respect to the proportions of PTs in nodules. The extent of this variation differed ($P < 0.01$) between species and was related to pollination characteristics. The homologous host for a particular soil consistently tended toward greater uniformity of nodulation with PTs than the heterologous host grown on the same soil. It is concluded that the legume host is an important factor determining the composition of its associated *Rhizobium* population. This has implications with respect to cropping regimes and the establishment of compatible legume-*Rhizobium* associations in the field.

Pseudomonas 4B isolated from the soil was found to be capable of fixing nitrogen with monomeric phenolic compounds as the sole carbon source. Nitrogen fixing activity of the bacteria was confirmed by $^{15}N_2$ incorporation and it was shown to contain genes with homology to the nitrogenase structural genes of *Klebsiella pneumoniae*. Comparable nitrogen fixing activities were observed under microaerobic conditions with either glucose or protocatechuate as carbon source. Since both pseudomonads and simple phenolic compounds are ubiquitous in nature, asymbiotic nitrogen fixation may be more important in many carbon-limited plant/soil environments than previously stipulated.

Physiology and biochemistry

The catalytic properties of the *Rhizobium meliloti* nitrogen fixing system in vivo (in nodules and bacteroids) were compared with those of the isolated nitrogenase proteins. Nitrogenase activity was maintained at temperatures below 10°C in vivo, whereas in vitro the nitrogenase proteins had very little activity in this temperature range. Nitrogen fixing nodules and to some extent bacteroids with respiration-coupled nitrogenase activity were shown to compensate for lower ambient temperatures by supplying more adenosine triphosphate (ATP) to the system than was available at 25°C. There may be additional compensating physiological factors that maintain nitrogenase activity at lower temperatures in vivo.

A newly discovered nitrogenase system of *Azotobacter chroococcum* was found to contain vanadium in place of the molybdenum of previously investigated nitrogenase proteins. This new system is coded for by an entirely different set of genes in this common soil organism. Vanadium nitrogenase allows nitrogen fixers to utilize N_2 as sole nitrogen source in the absence of molybdenum. This new system has been shown to be functional in other *Azotobacter* and some *Clostridium* species.

Nitrogen fixed in root nodules of alfalfa is combined in carbon compounds, of which at least one-eighth was demonstrated to come from carbon dioxide fixed by nodules. The acetylene customarily used to measure nitrogen-fixing activity partially inhibited it, the extent depending on the cultivar of alfalfa.

Molecular genetics

Analysis of Tn5 mutants of *Rhizobium meliloti* has revealed that three mutagens were responsible for their symbiotically defective phenotypes. One is ISRm1, a *R. meliloti* indigenous insertion sequence. A second is the intended mutagen, Tn5, which is responsible for about one-third of the phenotypes. A third mutagen has been discovered with unexpected properties. It inserts at high frequency into the *nod-nif* region and was responsible for about one-third of the mutations. This last category of mutagen does not produce physical alterations observable by probing, and thus must act by causing small or point mutations. The analysis of these mutants by Tn5-cloning and phenotypic complementation has revealed new genetic regions involved in symbiotic nitrogen fixation.

An analysis of rifampin mutants from strain JJ1-C10 and four other *R. meliloti* standard strains indicated that rifampin mutation in this species is invariably correlated with an altered RNA polymerase insensitive to the action of rifampin. This finding together with the fact that rifampin mutants of *R. meliloti* are less competitive for nodulation than the respective wild type strains indicate that the altered RNA polymerase may be less efficient at transcribing symbiotic genes.

ENTOMOLOGY

Population dynamics and integrated pest management (IPM)

Alfalfa weevil. Although populations of the weevil in the Bay of Quinte area began to subside in 1986, their numbers declined only slightly from 1985 levels. Life tables from several sites at the epicentre of the outbreak showed that the weevil has now been overtaken by its guild of natural enemies. Attacks on gravid females by asps of first-brood *Microctonus aethiopoides* (Loan) reduced egg deposition of spring adults by 31% and those of the second brood combined with *M. colesi* (Drea) to sterilize 55% of the summer adults prior to aestivation. Disease infections caused by *Erynia* spp., killed 91% of the feeding larvae and the survival rates fell to lowest levels since 1982. IPM scouting activities in the Bay of Quinte population epicentre led to treatment or early harvest of an estimated 40 000 ha of weevil infested first-cut alfalfa. The benefit–cost ratio for IPM was 10:1.

Alfalfa blotch leafminer (ABL). Populations of this European immigrant have undergone two distinct phases of numerical behavior since invading southern Ontario in the mid-1970s. During the early colonization phase, numbers increased rapidly for 3 or 4 years and then declined gradually to near tolerable levels because of maggot mortality from larval intraspecific competition and the numerical response of indigenous nabid and mirid predators. This pattern of events first occurred in the lower Ottawa Valley and was later repeated in the Bay of Quinte area, and beyond, as populations spread westward across the province in a succession of waves. A gradation to still lower levels began in the early 1980s. This coincided with mass propagation and release of the European wasp, *Dacnusa dryas* (Nixon), throughout southern Ontario. First colonized in the Ottawa area in 1979, this agent quickly became an important parasite of the ABL and has played a key role in stabilizing populations of its host. A sharp decline in ABL survival was recorded throughout the lower Ottawa Valley in 1982 and 2 years later in the Bay of Quinte area. During this latter period, the incidence of parasitism at five study sites ranged from 21 to 96%. An appraisal of 30 life tables showed that the activity of *D. dryas* accounted for almost two-thirds of the variation in ABL population trends. Since establishment of period, the incidence of parasitism at five study sites ranged from 21 to 96%. An appraisal of 30 life tables showed that the activity of *D. dryas* accounted for almost two-thirds of the variation in ABL population trends. Since establishment of this parasite, there has been a 100-fold depression in leafminer population densities, and numbers in eastern Ontario have declined to subeconomic levels. *D. dryas* is now distributed throughout southern Ontario and all of the major agricultural regions of Quebec.

Alfalfa snout beetle. In the spring of 1986, a major new discovery of the alfalfa snout beetle was made in eastern Ontario. Surveys showed that the infested area comprised about 9 km^2 of dairy farmland near the St. Lawrence River to the west of Prescott. Preliminary studies indicate that the pest reproduces parthenogenetically, has a 2-year life cycle, and attacks a wide range of forage and cash crops. Most of the damage is caused by the larvae; in alfalfa, the grubs feed on the lateral and tap roots, which are severed and excavated, and exposed to secondary root rots.

CEREAL CROPS

Wheat

Breeding. Excellent winter survival in the breeding nurseries and yield trials plus an unusually wet growing season gave ideal conditions to select for resistance to powdery mildew (*Erysiphe graminis* DC. ex Mérat), leaf rust (*Puccinia recondita* Rob. ex Desm. f. sp. *tritici*), and lodging. Most advanced lines were susceptible to one or both diseases but we have excellent resistance in early generations. The line 0-52-61-4 was promoted to the final year of cooperative testing. It is a good all-round line similar to the current cultivars in yield and pastry quality.

Further study of 171 F_6 lines from the winter wheat cross Lennox/Fredrick showed no correlation between kernel protein content and coldhardiness as measured in a freezing test ($r = -0.11$ Not Signif.). The frequency distribution of both traits was continuous and unimodal, suggesting complex inheritance.

Grain quality. Quantitative imaging techniques continue to be applied to the identification of important kernel characteristics in relation to milling and handling. A major phenolic acid, ferulic acid, occurs in extremely high concentrations in cereal bran and is being evaluated as a potential marker for bran contamination in mill-streams. In a collaborative study with Kansas State University, high-performance liquid chromatography has been shown to allow monitoring of bran content in mill fractions with unprecedented accuracy, and the procedure has considerable potential to replace older, less sensitive methods such as ash and color assays. New fluorescence reflectance methods now permit complete assessment of bran content in flours in under 30 s. Efforts are under way to translate these results to commercial milling systems and assessment of breeding lines.

Quantitative imaging techniques have been employed to identify kernel characteristics important in milling performance and grain classification systems. Digital image analysis procedures have been developed which allow all licensed varieties of Ontario soft wheats to be discriminated with greater than 95% accuracy.

Pathology. In central and eastern counties snow mold damage was light to moderate in winter wheat crops. *Typhula phacorrhiza* Reichard ex Fries was a component of the snow mold complex in several areas and it was associated for the first time with an instance of severe damage, resulting in crop failure. Inoculation studies indicated that isolates of the fungus differ in virulence. Dwarf bunt (*Tilletia controversa* Kuhn) occurred in localized areas of infested soil in western Ontario. Powdery mildew (*Erysiphe graminis* DS. ex Merat) developed extensively early in the season on most cultivars. Although all North American races of the pathogen have been found in Ontario, sources of resistance have been identified in disease nurseries. Cultivars and advanced lines of both white and red winter wheats were screened for resistance to prevalent races of loose smut (*Ustilago tritici* (Pers.) Rostr.). Low levels of loose smut occur annually in Ontario crops despite widespread use of recommended seed treatments. Fusarium head blight or scab (*Fusarium graminearum* Schw.) occurred at light to moderate levels throughout southern Ontario in 1986, with up to 80% symptomatic occurrence in fields near Lake Erie. In most areas the quality of wheat entering country elevators was lower than usual because of scab, sprouting, and effects of other diseases. Levels of vomitoxin in wheat at the farm level were higher than in 1985, but levels in shipments of soft white wheat for domestic consumption and export have been within established tolerances. Leaf rust (*Puccinia recondita* Rob. ex. Desm. f. sp. *tritici*) and septoria leaf blotch and glume blotch (*Septoria* spp.) were prevalent and locally severe, whereas stem rust (*Puccinia graminis* Pers. f. sp. *tritici* Eriks. & E. Henn.) was more prevalent than usual.

Physiology. Resistance to preharvest sprouting of entries in the Ontario winter wheat screening and cooperative tests and breeding programs was evaluated using a rain-simulator for intact spikes and a germination protocol on threshed grains. Fredrick showed the best sprouting resistance and Gordon the least, among the commercial cultivars. One line, OAC 82-14, was better than all the commercial cultivars. Five lines entered in the screening test were better than Fredrick and three of those, H 82-39, 0-90-5-10, and OAC 84-10, will be reevaluated in the 1987 Ontario cooperative test.

Barley

Breeding. The Plant Research Centre (PRC) cultivar Léger, released in 1982, serves as the new standard for yield and adaptability of barley in eastern Canada. A new disease-resistant strain, OB631-3, outperformed Léger in 1985 and 1986 and a request to register OB631-3 will likely be made in 1988 if it continues to perform well in 1987. A new two-row strain OB751-12, which is the first promising strain developed from this program, outperformed check varieties Rodeo and Birka in the 1st year of the two-row barley cooperative test. It will remain in the test to obtain more information for registration.

Pathology. Field studies with seed treatment fungicides for control of seed-borne *Pyrenophora graminea* S. Ito & Kuribay. showed that maneb (50% dust) was again the most effective of the fungicides registered for use on barley. Mancozeb and carbathiin were less effective, whereas several nonregistered fungicides gave excellent control of leaf stripe.

Oats

Breeding. The new PRC naked oat variety, Tibor, has performed well as a pig and poultry feed but extremely wet weather in 1986 prevented seed growers from obtaining high grain yields. A rates of seeding experiment revealed that Tibor should be sown at 56–70 kg/ha. The oat milling industry in Ontario is now reaping the benefit from the release of the PRC variety Donald and OAC Woodstock in 1982. Quaker Oats of Canada Limited, Peterborough, Ontario was able, for the first time, to purchase all its requirements for milling oats in Ontario and the oats were of acceptable quality. Stem and crown rust resistance has been added to Donald and the new line OA774-1 has performed well in official tests. Seed of an awned, completely naked-seeded oat (03669) is being increased rapidly in California and Ottawa to begin commercial food evaluation. It is anticipated that this oat will replace Tibor in time, especially for the food oat trade, because Tibor routinely possesses 5–7% covered seeds in threshed grain samples.

Grain quality. Fluorescence reflectance procedures have been developed for rapid and specific analysis of oat hull content in potential new varieties of milling oats. Fluorescence wavelengths were identified for specific detection of hulls in ground samples, and other wavelengths are being evaluated for their potential as rapid determinants of protein and fiber content. Using digital image analysis, studies are also under way to identify fundamental morphological parameters which contribute to oat milling quality.

Pathology. A long-time study of the virulence of isolates of stem rust (*Puccinia graminis* Pers.) occurring in eastern Ontario has shown that several races of oat stem rust (*P. graminis* f. sp. *avenae*) that are common to this area do not occur elsewhere in North America. These races probably have arisen through sexual recombination on common barberry (*Berberis vulgaris* L.), which has become naturalized in the area. Although barberry populations had been reduced to low levels following an intensive federal–provincial eradication program in the late 1960s, regrowth has occurred in many areas and the incidence of stem rust in cereal crops has increased. Races of stem rust have been detected in the barberry area that are virulent on resistance genes now deployed in new cultivars of oats recently developed for western Canada. Reactivation of programs to eradicate common barberry from cereal growing areas in Ontario is recommended. Crown rust (*Puccinia coronata* Cda.) was less prevalent than usual but progress has been made in selecting oat lines showing resistance to this disease.

Physiology. Two seed treatments were investigated on dormoat PGR8658, PGR16728, and DC 1358-7 to improve their field spring emergence following a fall planting. Seed stratification for 3 weeks and seed incubation at 30°C for 1 week, plus early and late planting controls, were used; the two treatments were planted late. In laboratory assessment, each dormoat showed secondary dormancy induction with both treatments. In the field, the treatments did not improve the fall percentage of the seed population entering winter as dormant seeds. Winter survival and spring emergence were improved over the late planted control for both PGR16728 and DC 1358-7. The best emergence for the three dormoats was, however, from the early planted control.

FORAGE CROPS

Corn

The year 1986 was an abnormal one climatically. The heat unit accumulation was below normal and rainfall 70% above normal. Plant development was about 7–10 days later than normal, and full season lines failed to produce high-quality seed. Two new corn hybrids were supported for licensing: OX 802 in Ontario and OX 788 in Manitoba. OX 802 is a three-way cross (2800 corn heat unit – CHU) with good stalk quality and yield potential in the major corn region of Ontario. OX 788 is rated at 2215 CHU in Manitoba, having a very high yield/moisture index, and good stalk and root quality.

In cooperative trials with Lethbridge, Brandon, Morden, Saint-Jean, L'Assomption, and the universities of Manitoba and Guelph, hybrids earlier and higher yielding than the previous earliest check have been identified. The earliest hybrids require just over 2000 CHU. Some will achieve licensing in 1987. A new mechanism has been established to release inbred lines to the commercial seed sector. As a result the program will be directed toward the development and release of superior inbred lines for the low CHU regions.

Pathology. Ear rot was severe in most corn fields in eastern Ontario, in 1986. A survey was carried out to determine if differences in tolerance to *Fusarium* spp., were present in the group of hybrids recommended for the area. Examination of ear samples of 54 hybrids from test plots at 21 locations demonstrated that *Fusarium moniliforme* (Sheldon) Snyd. & Hans., or *Fusarium roseum* var. *graminearum* (Schwake) Snyd. & Hans., were present on 25% of the 8200 ears examined. The average infection rate of individual hybrids growing in several locations ranged from 5 to 40%.

Alfalfa

Clones of Alfalfa (*Medicago sativa* L.) having resistance to bacterial wilt (BW), *Corynebacterium insidiosum* (McCull.) H.L. Jens., and verticillium wilt (VW), *Verticillium albo-atrum* Reinke & Berth. (*Vaa*) were further screened in the greenhouse, using a new technique for simultaneous selection of plants with resistance to these diseases. Polycross populations from the resultant selections are being grown to produce seed.

Evidence of N benefit from legumes to companion grasses was obtained from field experiments conducted during the past 3 years, using the ^{15}N dilution technique. This benefit contributed from 3 to 40% of total N yield of companion grasses, depending upon plant species and stages, legume populations in mixture, and management and environmental conditions. Greater N_2-fixation capacity of legumes (alfalfa as compared to red clover and bird's-foot trefoil) resulted in increased N transfer to companion grasses. Earlier maturing orchardgrass and tall fescue seem to benefit more from the N fixed by companion legumes, especially in the later stages of stand establishment. Long days in combination with high light intensities and a high temperature (25°C) are the best conditions for N fixed and transferred by alfalfa. Results suggest that both direct excretion and gradual release of N from the decomposition of dead legume tissues are involved. Inoculated alfalfa roots grown hydroponically under axenic conditions excreted a range of N compounds (ammonium, glutamate, alanine, serine, gaba, and aspartate) to the surrounding medium. Experiments selecting individual plants for high and low N excretion are being conducted, with crossing to test heritability.

Testing of alfalfa (*Medicago sativa* L.) cultivars for resistance to phytophthora root rot (*Phytophthora megasperma* Dresch. f. sp. *medicaginis* Kaun & Erwin) showed that the percentage of resistant plants (% R) was highly correlated with the disease severity index (DSI). There was a strong correlation between disease assessments made under field and greenhouse conditions.

Soybean

Line OT83-4 was licensed as Maple Donovan and Breeder Seed distributed to producers by SeCan Association. Seed producers reported excellent yields and better than average seed quality. Line OT84-12 and OT84-14BR were supported for licensing by the Ontario Oil and Protein Seed Crops Committee. Results for 1986 confirm that OT84-12 is about 10% higher in yield than Maple Arrow. The high-pod line K618-1-2-1 (OT86-3) was entered in both Ontario and Quebec trials and produced yields 97% of Maple Arrow and with lower pods 3 cm higher from the soil. Oil content, however, was two percentage points below that of Maple Arrow. Two small-seeded natto type lines, OT85-8 and OT84-3, have higher yield and slightly smaller seed than Canatto and if they are equal or superior in quality will be put forward to replace or supplement Nattawa and Canatto in the Japanese market. Progeny testing and seed increase has been completed for the partially photoperiod insensitive isoline of Harosoy and for the fully insensitive isoline of Maple Arrow. Nursery selections of tall determinate types with earlier maturity, photoperiod insensitivity, and improved lodging resistance were made.

Effects of brown spot (*Septoria glycines*) alone or in combination with bacterial blight (*Pseudomonas syringae* pv. *glycinea*) on four soybean cultivars were evaluated in field plots at Ottawa. The effect of brown spot was greater than bacterial blight in terms of foliage infection. Bacterial blight was not associated with yield loss but a loss of 13–15% in seed yield was caused by the brown spot disease, indicating its economic importance.

Grasses

The forage grass program is focused on cultivar development and investigation of the genetics and breeding behavior of autopolyploid forages. An orchardgrass (*Dactylis glomerata* L.) strain (Or-WH) selected for winterhardiness exceeded the mean check yield in licensing trails in Quebec. Previous tests indicate that its persistence is similar to Kay, a very winterhardy cultivar. Freezing tests were conducted on two winter-hardy populations of switchgrass (*Panicum virgatum* L.). In August, all plants survived −2°C but none survived −4°C. By December, over 80% of the plants in each population survived −20°C. The percentage of crown moisture does not appear to be a good indicator of LT50. Field-grown plants began developing a "dormancy" by early September. When clipped and repotted in the greenhouse, temperatures above 30°C were required to stimulate regrowth. Significant differences were found for yield and several quality parameters among timothy (*Phleum pratense* L.) plants grown in replicated simulated swards at Ottawa and at Fredricton, N.B. Mean acid detergent fiber levels ranged from 32.8 to 37.8%, indicating considerable scope for selection. The levels of soluble carbohydrates were higher in Fredricton (9.5–14.7%) than in Ottawa (4.1–8.8%).

PLANT GENE RESOURCES OF CANADA (PGRC)

Plant genetic resources are the "raw materials" that plant breeders use to create improved plant varieties. The PGRC office is the essential element of a national program whose goals are to obtain, maintain, and conserve collections of crop genetic material, to organize national and international exchanges of germ plasm, and to provide information and documentation on all of the above.

Over 80 500 seed samples of diverse crops are stored under controlled conditions at PGRC. We maintain Canada's national base collection (CN; 18 000 samples) and national active collection (PGR; 17 500 samples), and participate in international gene bank activities. PGRC stores principal world base collections of oats, barley, and duplicate collections of pearl millet. The National Apple Repository Network, which involves six Agriculture Canada research stations across the country, preserves almost 200 apple stocks. Last year, 4960 PGRC accessions involved 382 exchanges of germ plasm with individuals and institutions in 39 countries.

Information on the Canadian national collections (oats, barley, wheat, tomato, and alfalfa) is stored in computerized data banks. Genetic resources inventories are published periodically, listing cultivars and genetic stocks under a number of traits or descriptors. The PGRC newsletter, published semiannually, reports on activities concerning plant genetic resources. It has a mailing list of 501 in Canada and 255 in 49 other countries.

PGRC provides a focus for Canadian activities in plant genetic resources by participating in policy development, initiating and encouraging projects all across the country.

ELECTRON MICROSCOPY SERVICE

Over 90 professional and technical staff of establishments on the Central Experimental Farm and nine outside agencies (universities, other government departments, Canadian Red Cross, and foreign visitors) made use of the facilities of the Electron Microscopy Unit.

Special research projects were undertaken for the Prince Edward Island Potato Marketing Board, the Canadian Red Cross, the National Museum of Natural Sciences, and the National Research Council.

Research carried out at the unit was reported in 29 research papers and in several reports concerned with methodology development; chemical analysis; biosystematics of plants and insects; ultrastructure of fungal zoospores, cultured plant cells and their membranes; microstructure of hens' eggshell, yogurt, and other dairy products; detection of plant pathogenic mycoplasmas and viruses in infected tissues; image analysis of time-lapse videotapes of thromboembolism; and confirmation of freedom from virus infection in potato seedlings. These publications are listed in individual reports of research centres and stations.

Users of the instrumentation at the unit were trained in the use of ISI-DS-130 scanning electron microscope, the Philips-300 transmission electron microscope, the T-N 5500 X-ray spectrometer system, the Toussimis critical-point dryer, image analyzer, the Blazers freeze-etch unit, the Hexland cold stage attached to AMR 1000 A scanning electron microscope, and the Hummer 11 goldcoating unit. New acquisitions to the unit were the DSK microslicer and the RMC propane jet freezer. Methods to optimize high resolution performance of the scanning electron microscope were developed at the unit.

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Atlantic Region
Région de l'Atlantique

Y.A. Martel

W.B. Collins

Director General *Directeur général*	Y.A. Martel, B.A., B.Sc.(Agr.), Ph.D.
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Acting Chief, Administrative Services *Chef des Services d'administration, intérimaire*	J.E. Jeffery

PREFACE

The Atlantic Region, with headquarters in Halifax, consists of four research stations, two experimental farms, and two substations. These research establishments serve the agricultural communities in New Brunswick, Prince Edward Island, Nova Scotia, and Newfoundland. In addition, the regional establishments make major contributions to national programs on potatoes, food processing, livestock feeds and nutrition, postharvest storage, and control of insects, diseases, and weeds. In 1986, the region managed a budget of $20 million and employed 100 professionals to carry out its programs.

The soil management program is developing practical management technology to cope with problems of erosion, drainage, and the physical constraints related to impermeable subsoils and the potential of peatland resources in the region. Crop production potential and management procedures for soils and crops leading to reductions in erosion losses are used in soil evaluation.

The livestock and livestock feeds research program is developing improved feeding and management systems with emphasis on the utilization of locally produced feedstuffs for beef and dairy cattle, swine, poultry, and sheep operations in the region. Ruminant nutrition is related to forage research whereas all animal research is related to cereals research. There is also work conducted on livestock and poultry diseases, physiology, reproductive physiology, and basic aspects of metabolism.

The cereal research program is developing and identifying superior cereal cultivars that meet regional requirements for yield, disease resistance, cold tolerance, and climatic adaptability. Breeding and evaluation are currently conducted on spring and winter wheat, spring barley, and conventional and hull-less oats. Studies are also in progress on fusarium species, winterhardiness, cereal management, fertility requirements, effectiveness of growth regulators, and interaction of inputs.

The forage crop research program is developing superior forage management techniques, breeding and testing new forage varieties, developing conservation technology, and assessing forage persistence and winterhardiness. Forage research is closely tied to the programs on soil fertility and drainage, and forages are evaluated by feeding the product to ruminants.

The horticultural crops research program is separated into potatoes, other vegetables, tree fruits, berries, and ornamentals. Potatoes involves the national breeding project; evaluation of potential new varieties; assessment of diseases, their control, and measurement; measurement of physiological parameters; and handling techniques. Other areas of horticulture involve variety assessment, yield comparison, disease resistance screening, and management technology development. There is also a small program in tobacco variety evaluation recorded under field crops.

Processing technology and storage research is directed to improving the competitive advantage of regionally produced products for both the domestic and export markets. The majority of the work is related to fruit and vegetable processed products and increasing the storage life with a controlled atmosphere.

Significant staff changes in 1986 included the departure of Dr. Harmon Davidson, director of the St. John's Research Station, and the departure of Dr. Y.A. Martel, director of the Fredericton Research Station. Dr. Martel has been appointed director general for the Atlantic Region. Mr. Ken Proudfoot has been acting director at St. John's and Dr. G. Misener at Fredericton.

Further information about our programs may be obtained by writing to the research establishment concerned or by addressing inquiries to Eastern Region Headquarters, Research Branch, Agriculture Canada, 930 Carling Avenue, Ottawa, Ont. K1A OC5; Tel. (613)995-7084.

Y.A. Martel
Director General

PRÉFACE

La Région de l'Atlantique, dont l'administration centrale se trouve à Halifax, comprend quatre stations de recherches, deux fermes expérimentales et deux stations satellites. Ces établissements dispensent leurs services aux collectivités agricoles du Nouveau-Brunswick, de l'Île-du-Prince-Édouard, de la Nouvelle-Écosse et de Terre-Neuve. Par ailleurs, ils contribuent considérablement aux programmes nationaux suivants: pomme de terre; transformation des aliments; aliments pour bestiaux et nutrition animale; entreposage des récoltes; lutte contre les insectes, les maladies et les mauvaises herbes. En 1986, la région gérait un budget de 20 millions de dollars et employait 100 professionnels pour mener à bien ses programmes.

Dans le cadre du programme d'aménagement des sols, les chercheurs mettent au point des pratiques d'aménagement destinées à résoudre les problèmes d'érosion et de drainage, ainsi que les contraintes physiques liées aux sous-sols imperméables et à l'exploitation éventuelle des tourbières de la région. Pour évaluer les sols, les chercheurs essaient des productions végétales et des méthodes de travail du sol et de culture qui permettraient de réduire éventuellement l'érosion.

Les chercheurs qui travaillent au programme consacré aux bestiaux et à leur alimentation mettent au point des régimes d'alimentation et des pratiques d'élevage susceptibles d'accroître l'utilisation du fourrage produit localement pour les bovins de boucherie et les bovins laitiers, les porcs, la volaille et les ovins. La nutrition des ruminants s'intègre aux recherches sur les fourrages, mais les recherches zootechniques sont liées aux travaux sur les céréales. Les chercheurs se penchent également sur les maladies des bestiaux et de la volaille, sur la physiologie générale et celle de la reproduction et sur les aspects fondamentaux du métabolisme.

Les recherches sur les céréales sont axées sur la création et l'identification de cultivars supérieurs susceptibles de répondre aux besoins régionaux sur le plan du rendement, de la résistance aux maladies, de la tolérance au froid et de l'adaptabilité au climat. La sélection et l'évaluation des variétés portent sur le blé de printemps et d'hiver, l'orge de printemps et les avoines régulière et nue. Les études portent également sur le genre *Fusarium*, la résistance au froid, les pratiques culturales pour les céréales, les exigences liées à la fertilité, l'efficacité des régulateurs de croissance et l'interaction des facteurs de production.

Les chercheurs qui travaillent sur les fourrages améliorent les techniques culturales, sélectionnent et essaient de nouvelles variétés, mettent au point des techniques de conservation et évaluent la pérennité et la résistance à l'hiver des plantes fourragères. Ces travaux sont étroitement liés aux recherches sur la fertilité et le drainage des sols. Les chercheurs évaluent les fourrages en les incorporant aux rations des ruminants.

Le programme de recherches horticoles inclut la pomme de terre, d'autres légumes, les fruits de verger, les petits fruits et les plantes ornementales. Les recherches sur la pomme de terre englobent le programme national de sélection; l'évaluation de nouvelles variétés; les maladies et les moyens de lutte et d'évaluation; les paramètres physiologiques; les techniques de manutention. Les autres domaines couverts en horticulture sont l'évaluation des variétés, la comparaison des rendements, la sélection pour la résistance aux maladies et la mise au point de techniques culturales. Ces travaux intègrent également, du côté des cultures de grande production, un petit programme d'évaluation des variétés de tabac.

Les recherches axées sur les techniques de transformation et sur l'entreposage visent à améliorer la compétitivité des produits régionaux sur les marchés intérieurs et étrangers. La plupart des travaux portent sur les fruits et les légumes transformés et sur le prolongement de la période de conservation grâce à l'entreposage en atmosphère contrôlée.

En 1986, la composition du personnel a subi de profonds changements avec le départ du D^r Harmon Davidson, directeur de la Station de recherches de St. John's West, et celui du D^r Y.A. Martel, directeur de la Station de recherches de Fredericton. Ce dernier a été nommé directeur général pour la Région de l'Atlantique. M. Ken Proudfoot et le D^r G. Misener ont travaillé en qualité de directeurs par intérim à St. John's et à Fredericton respectivement.

Pour obtenir de plus amples renseignements sur nos programmes, il faut écrire à l'établissement de recherches concerné ou adresser les demandes à l'Administration centrale de la Région de l'Est, Direction générale de la recherche, Agriculture Canada, 930, avenue Carling, Ottawa (Ontario) K1A 0C5. On peut également téléphoner au (613) 995-7084.

Y.A. Martel
Directeur général

Research Station, St. John's West Newfoundland

PROFESSIONAL STAFF

K.G. Proudfoot, B.Agr., M.Agr.	Acting Director

Horticulture

B.G. Penney, B.Sc., M.Sc.	Vegetable crops

Plant Breeding and Pathology

K.G. Proudfoot, B.Agr., M.Agr.	Program Leader; Plant breeding
M.C. Hampson, B.Sc., M.Sc., Ph.D.	Plant diseases

Agricultural Engineering

G.A. Bishop, B.Eng., M.A.Sc.	Agricultural machinery

Entomology (Vacant)

Agronomy (Vacant)

Departures

H.R. Davidson, B.Sc., Ph.D., P.Ag. Transferred to Commodity Coordination Directorate, Policy Branch, Ottawa, November 1986	Director

INTRODUCTION

The Research Station located at St. John's West is responsible for agricultural research in Newfoundland and Labrador. Plant breeding includes the development of potato cultivars resistant to potato wart disease and golden nematode, and rutabagas resistant to clubroot disease. The plant pathology program concentrates on studies of the potato wart disease organism. The entomology program has investigated insect pests of horticultural and forage crops, and maintains an extensive collection of Newfoundland insects. Research on the development and utilization of peat soils for horticultural and forage production is conducted at the Peat Research Substation, Colinet, and the management of lowbush blueberry stands, at the Avondale Substation.

This report provides brief summaries of some of the results obtained in 1986. Further information, reprints of listed publications, and copies of previous reports can be obtained from the Research Station, Research Branch, Agriculture Canada, P.O. Box 7098, St. John's, Nfld. A1E 3Y3; Tel. (709) 772-4619.

K.G. Proudfoot
Acting Director

HORTICULTURE

Peat soil

Plots were established on three commercial peat soil sites with transplanted midseason cabbage (cultivar Stonehead), late cabbage (cultivars Bartolo and Houston Evergreen), and celery (Stokes Improved Utah 52-70). Treatments evaluated were as follows: 15-10-15 plus 6% FTE503 fertilizer applied before planting at rates of 3000, 3500, and 4000 kg/ha, with and without black plastic mulch, and split applications (half before planting and half as a sidedressing) of the same rates without mulch; and 10-14-20 plus 8% FTE503 fertilizer applied before planting at rates of 2250, 2625, and 3000 kg/ha with sidedressings of ammonium nitrate at 662, 772, and 882 kg/ha, respectively, without mulch. All plots except those covered by black plastic mulch were hand-weeded frequently to maintain weed-free conditions.

Midseason cabbage. Marketable yields were excellent at all sites (mean yield of 57.5 t/ha). There were no significant differences among fertilizer treatments with or without black plastic mulch.

Late cabbage. Marketable yields were low at all sites (mean yield of 19.4 and 23.2 t/ha for Bartolo and Houston Evergreen), probably as a result of high plant density, resulting in loose-leaved heads. There were no significant differences among fertilizer treatments with or without black plastic mulch.

Celery. Marketable yields were excellent at all sites (mean yield of 79.3 t/ha). There were no significant differences among fertilizer treatments. Although black plastic mulch did an excellent job of controlling weeds, marketable yields were reduced by 19.7% when compared with yields from hand-weeded plots receiving the same rates of preplant fertilizer. This yield reduction may have been a result of nutrient leaching, water-logging, or both, caused when the plastic mulch became concave after installation.

Cabbage root maggot control. Early and late cabbage and rutabaga seedlings were grown in a soil mix in which the granular insecticide fensulfothion was incorporated at the rates of 0.5 g or 1.0 g/900 g soil mix. These treatments were compared with a liquid drench of a solution containing 2.5 mL fensulfothion in 1 L water applied to seedlings 5 days before transplanting, at the rate of 20 mL per plant; the treatments were also compared with an untreated control at St. John's and Wooddale (central Newfoundland). At St. John's, plant losses of 85% for early cabbage, 80% for rutabagas, and 30% for late cabbage occurred in untreated plots. The drench treatment resulted in reductions in yield of late cabbage at Wooddale and of early cabbage at both centres. However, market yields of rutabagas were higher at both centres with the drench treatment.

Mineral soil

Lowbush blueberry. In 1983 a study was initiated with the objective of improving productivity from natural stands. Treatments evaluated were factorial combinations of two levels each of N (0, 60 kg/ha), P (0, 26.2 kg/ha), and K (0, 49.8 kg/ha) fertilizer; two dates of fertilizer application (sprout or crop-year applications); and two levels of weed control (with and without chemical treatment).

Production in 1984 and 1985 was low, primarily a result of extensive flowerbud winter-kill, and consequently little benefit was evident as a result of treatments. In 1986, however, production was high, and the mean yield from plots where weeds were controlled and N fertilizer was applied was 4129 kg/ha, compared with 1038 kg/ha from plots without these treatments.

PLANT BREEDING AND PATHOLOGY

Potato breeding

The first selection resistant to both wart disease and cyst nematode has been released as the cultivar Cupids, and despite its susceptibility to common scab has been favorably received by some growers.

In the crossing program, emphasis continues to be placed on crossing cultivars or selections resistant to common scab with cultivars resistant to warts and cyst nematodes. Crosses have also been made to produce seedlings with a reduced susceptibility to greening on exposure to light, using a range of material supplied by Dr. A.F. Reeves of the University of Maine. A number of recently introduced North American cultivars and advanced selections included in NE107 trials were assessed for wart susceptibility at Avondale. The cultivars Hampton and Chipbelle, which had been free of infection in previous trials, were again uninfected. Elba, Islander, Nemarus, Norking Russet, Rhine Red, Sunrise, Tolas, Yankee, and Chipper and Selections NY71, AF236-1, and CS7232-4 were found to be susceptible.

Rutabaga breeding

In most trials conducted to date, selection RST has remained free from clubroot infection. Growers have had excellent results in using RST for the production of transplanted rutabagas for the high-priced early market; well-colored, well-shaped roots have been produced. Bolting occurred in some early-planted crops but was of minor concern. The selection RST has been proposed to be released as the cultivar Kingston. Observation plots of the U.S. cultivar Pike, the English cultivar Angela, and the New Zealand cultivar Kiri were established in clubroot-infested soil. Kiri produced poorly shaped roots that were mostly disease free; Angela had attractively shaped, well-colored roots with moderate levels of clubroot; and the roots of Pike were not attractive in shape and were severely infected with clubroot.

Plant pathology

Soil amendments. Counts of resting spores of *Synchytrium endobioticum* were made in plots planted to tubers, left fallow, or treated with two levels of powdered crab meal. Density values of resting spores varied weekly, but little difference in number was found between treated and untreated areas. In the greenhouse, amendment tests were carried out throughout the year with urea, glucose, glucosamine, N-acetylglucosamine, chitin, crab meal, ammonium nitrate, peat, and calcium carbonate. Crab meal successfully suppressed potato wart disease. Chitin and its derivatives suppressed the disease but were not as effective as crab meal. Less control occurred with urea, glucose, and ammonium nitrate.

Disease suppression was not particularly successful when tubers were treated with carboxymethyl cellulose or with potato starch mixed with chitin or crab meal, or with both treatments. The effect of sterilizing soil on the efficacy of chitin as a disease suppressant was also examined. Results were inconclusive, as soil sterilization reduced the suppressive effect only in some instances.

Germination. Resting spores separated from wart tissue on plants previously treated with polyoxin D showed enhanced germination. Resting spores incubated in polyoxin D also showed enhanced vesicle formation. In other work, counts were taken of vesicles appearing in incubation vessels. These vessels were prepared monthly with freshly harvested resting spores and read at 2–3 day intervals for three-quarters of each month. Analysis of these results showed a tendency for germination to rise in at least two peaks during the year.

Bioassay. Nodal propagants were grown aseptically under standardized conditions in a growth chamber until they filled a 250-mL Erlenmeyer flask, ditions in a growth chamber until they filled a 250-mL Erlenmeyer flask, when they were transplanted to infested mix. Such inoculated propagants consistently contracted wart disease. An 80% infection of nodal propagants was recorded when they were planted into a mix infested with spores treated in 2% chlorine bleach for 8 min.

AGRICULTURAL ENGINEERING

During 1986, modifications to the hydraulic system and improvements in machine flotation were made to a commercial carrot harvester to improve its performance on organic soil. A plow point was also reinstalled to loosen the carrots from the peat.

For land preparation a rear-mounted screw leveller 2.5 m wide was imported from Ireland. Testing at Colinet and St. Shott's showed that the machine was very effective in field crowning, permitting rapid runoff of rainwater. A chain-type trencher worked well in dry conditions, but some problems were encountered in wet peat, with the peat sticking to the chain.

PUBLICATIONS

Research

Hampson, M.C. 1986. Sequence of events in the germination of the resting spore of *Synchytrium endobioticum*, European pathotype 2, the causal agent of potato wart disease. Can. J. Bot. 64:2144 – 2150.

Research Station, Charlottetown Prince Edward Island

PROFESSIONAL STAFF

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M.B. Bourdon, D.Journ.	Information Officer
B.L. McFarlane, B.Sc.(Biol.), M.Sc.	Technology Development Program (ERDA) Projects Officer
B.J. Murray	Administration Officer

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L.M. Edwards, B.Sc., M.Sc., Ph.D.	Soil management
U.C. Gupta, B.Sc.(Agr.), M.Sc.(Agr.), Ph.D., F.C.S.S.S., F.A.S.A., F.S.S.S.A.	Soil and plant micronutrients
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R.G. Andrew,[2] B.Sc.(Agr.)	Agricultural economics
P.R. Narasimhalu,[3] B.Sc., B.V.Sc., M.S., Ph.D.	Forage conservation and utilization
M. Suzuki, B.Sc., Ph.D.	Forage and cereal biochemistry and physiology
K.A. Winter, B.Sc.(Agr.), M.Sc., Ph.D.	Animal nutrition

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J.A. Cutcliffe, B.Sc.(Agr.), M.Sc.	Head of Section; Vegetable nutrition and management
W.J. Arsenault, B.Sc.(Agr.)	Tobacco management and nutrition
J.A. Ivany, B.Sc.(Agr.), M.S., Ph.D.	Field crop weed control
J. Kimpinski, B.S.A., M.Sc., Ph.D.	Nematology
H.W. Platt, B.Sc., Ph.D.	Potato diseases
D.C. Read, B.Sc.(Agr.), M.Sc., Ph.D.	Pesticide degradation, vegetable insects
J.B. Sanderson, B.Sc.(Agr.), M.Sc.	Potato management and fertility
J.G. Stewart,[4] B.Sc., M.Sc.	Biologist in training
R.P. White, B.S.(Ed.), M.S., Ph.D.	Potato and corn nutrition and management, soil chemistry

Departure

J.G. McDonald,[5] B.Sc.(Agr.), M.Sc., Ph.D.	Potato virus diseases

VISITING SCIENTIST

L.J. Halliday,[6] B.Sc., Ph.D.	Ruminant nutrition

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[1] Seconded from Libraries Division, Corporate Management Branch.

[2] Educational leave, University of Alberta.

[3] Transfer of work to Swedish Agricultural University and Université Catholique de Louvain, Belgium.

[4] Educational leave, University of Guelph, Guelph, Ont.

[5] Transferred to Food Production and Inspection Branch, Agriculture Canada.

[6] Postdoctoral fellow to December 1986.

INTRODUCTION

The research station at Charlottetown has Atlantic Region responsibility for research on the production and utilization of livestock feed crops (forages, cereals, protein), tobacco, and certain vegetable crops (cole, peas) grown for processing. Emphasis on potato research is in the areas of nutrition and management for processing and table potatoes, but especially for small whole-seed potato production. Research is also conducted on disease evaluation and control.

In November, Dr. Pushpal Narasimhalu began a 1-year transfer of work to the Swedish University of Agricultural Sciences, Uppsala, Sweden, to work on using plant growth regulators to modify forage crop quality (6 months) and to the Université Catholique de Louvain, Belgium, to study the effect of newer forms of enzyme additives on silage fermentation and quality.

Rollin Andrew, research economist, is undertaking an M.Sc. program in production economics at the University of Alberta, Edmonton, and Dr. Jeff Stewart, biologist-in-training, is completing a Ph.D. program in integrated pest management at the University of Guelph.

Dr. Leslie Halliday, a postdoctoral fellow, continues his research on forage degradation in the rumen as it relates to forage quality.

Dr. John McDonald, potato virus researcher, was transferred to the Plant Health Laboratory of the Food Production and Inspection Branch, Ottawa, in March, to assume the post of chief of the Pathology Section. The potato virus research program at Charlottetown has been terminated.

This report includes brief summaries of some of the research completed in 1986. More detailed information may be obtained by referring to the station's research summary, which is published annually, or by contacting the Research Station, Research Branch, Agriculture Canada, P.O. Box 1210, Charlottetown, P.E.I. C1A 7M8; Tel. (902) 892-5461.

L.B. MacLeod
Director

CEREAL CROPS

Breeding and testing

Winter wheat. The milling cultivar Absolvent was registered for the Atlantic Region. Absolvent, developed by Dr. P. Franck in West Germany, was evaluated extensively in regional trials and was found to possess winterhardiness superior to Monopol. The new cultivar yields slightly more than Monopol in the Atlantic Region. It is susceptible to *Septoria* and powdery mildew and must be grown under intensive management to obtain high yield and adequate disease control.

Diseases and pests

Airborne Fusarium population in wheat. A "Jet" through spore trap was used to estimate the daily spore load of viable *Fusarium* spores within a wheat field. Spores were collected on pentachloronitrobenzene (PCNB) media in petri plates located within the spore trap's settling chamber. Plates were incubated, and after they were enumerated, colonies were subcultured and *Fusarium* species identified. Predominant species collected during August of 1985 were *F. avenaceum* (33.1%), *F. graminearum* (30.5%), and *F. sporotrichiodes* (30.3%). Nine other *Fusarium* species were positively identified at levels between 0.1 and 1.3%. The main species recovered from wheat heads were similar to those recovered from the air, although *F. poae* was recovered much more frequently from the heads than from the air.

Several oat lines exhibit tolerance to barley yellow dwarf virus disease. A number of oat lines were chosen for field testing from the maritime cooperative oat test, to compare with Sentinel for tolerance of barley yellow dwarf virus disease. Sentinel is an oat variety currently grown in the region and exhibits some tolerance for barley yellow dwarf virus disease. Lines chosen to compare with Sentinel were lines subjected to advanced testing, which could be licensed as varieties recommended for the Atlantic Region. The Quebec oat lines 209-32, 505-2, 191-70, 186-10, and 199-60 and Ottawa oat lines 516-2 and 447-11 exhibited a greater tolerance for barley yellow dwarf virus disease than did Sentinel oats. Quebec oat lines 191-70, 186-10, and 199-60 are licensed as the varieties Nova, Marion, and Cardinal, respectively, and may be suitable varieties to grow when late seeding is necessary and the risk of barley yellow virus disease is high. The *Atlantic Provinces Field Crop Guide* for 1987 recommends Marion as an early maturva, Marion, and Cardinal, respectively, and may be suitable varieties to grow when late seeding is necessary and the risk of barley yellow virus disease is high. The *Atlantic Provinces Field Crop Guide* for 1987 recommends Marion as an early maturing, high-yielding oat variety.

Fungal diseases and nematode levels. The effects of aldicarb on populations of root lesion nematodes (*Pratylenchus* spp.) and on grain yields of spring barley and wheat were examined in experimental plots over 3 years. The incidence of barley net blotch (*Pyrenophora teres*), wheat leaf blotch (*Leptosphaeria nodorum*), and common root rot (*Cochliobolus sativus*) were also recorded for 2 years. Temik G (15% aldicarb) with active ingredient (a.i.) at a rate of 3.36 kg/ha, applied broadcast at planting, reduced the size of root lesion nematode population in all cases. The severity of leaf diseases was decreased during one year, but the incidence of root rot was not affected by the treatment. Yields of cereal grain were increased by approximately 15% when aldicarb was applied.

Nematodes in wild rice. The rice root nematode *Hirschmanniella pisquidensis* was the dominant nematode species recovered from roots of wild rice (*Zizania palustris*) on Prince Edward Island. Roots that harbored large nematode populations were discolored. Yields were not recorded, but studies in paddy rice in Asia have indicated that large numbers of rice root nematodes can reduce yields.

SOIL MANAGEMENT AND CONSERVATION

Management

Effectiveness of liming in overcoming molybdenum deficiency in crops on acid soils. The molybdenum (Mo) requirement of alfalfa and cauliflower on a sandy loam soil was not totally met by liming. Some addition of Mo was necessary to achieve maximum yield and to overcome the problem of Mo deficiency. Liming a silty clay loam soil to pH 6.5 eliminated the Mo deficiency in these crops. The Mo-supplying power of the various soils as related to liming differed considerably. Liming to pH 6.9 or above was detrimental to alfalfa and cauliflower yields.

Tillage

Soil structure under no-till corn production. The spatial variability of soil strength, porosity, and microbial biomass was determined under continuous direct-planted silage corn (*Zea mays* L.) after 4 years. All soil properties changed relative to the row position. Microbial biomass C and N was lower in the in-row compared to the between-row position. Positional and depth differences for soil bulk density and volume of macropores were only evident at the soil surface (0–8 cm). Temporal and spatial variations in soil strength indicated the extent of the rooting potential within the soil profile, the depth to compacted soil layers, and the degree of soil structure regeneration during the winter period.

Effect of direct drilling for Italian ryegrass on soil structure. The physical, biological, and chemical condition of the soil was assessed under cultivated and direct-drilled systems for the annual establishment of Italian ryegrass (*Lolium multiflorum* Lam.). After 3 years, the degree of tillage-induced soil compaction and a change in soil biological and chemical properties were determined over the soil depth of 0–24 cm and were compared with the soil structure under a permanent timothy (*Phleum pratense* L.) pasture. The study was conducted at two sites on a Charlottetown fine sandy loam, an Orthic Humo-Ferric Podzol (Haplorthod). Although the tillage comparisons produced significant changes in soil porosity, pore-size distribution, pore continuity, aggregation, and soil strength, the range in physical properties was within the optimum range for soil structure. Soil strength was shown to exhibit marked temporal variation over the growing season. Changes in the distribution of soil microbial biomass C and N, percentage of organic C, pH, and plant nutrients were evident between the establishment methods. Generally, chemical and biological conditions of the soil under direct-drilling were similar to those under permanent pasture. Comparison of the actual with the estimated maximum bulk density down the soil profile indicated that the propensity for soil consolidation or compaction was the same under the direct-drilling and cultivated systems and similar to that measured under permanent pasture. The annual establishment of Italian ryegrass, for 3 years, by direct-drilling did not adversely affect soil structure or increase soil compaction.

FORAGE AND LIVESTOCK

Forage management and physiology

Nitrogen management for orchardgrass. The combined effects of rate and timing of ammonium nitrate applications on orchardgrass (*Dactylis glomerata* L.) in the field were studied over a 5-year period. Nitrogen (N), in the form of ammonium nitrate, was applied at 40–120 kg/ha in either spring or summer or in split applications. Orchardgrass was cut two or three times during each growing season. Single applications of N in spring increased annual yield by about 11% over equivalent applications in summer. For split applications no significant difference in annual yield was found, regardless of whether the greater fraction was applied in spring or summer. A second-order polynomial was found to explain almost all of the variation in the response curve over time for dry-matter yield. Application of N at 120–165 kg/ha was required to maintain a uniform yearly dry-matter production. There was variation in the mean seasonal N concentration over years but with few clear trends. The N concentration in cuts 1 and 2 was determined principally by the rate of N applied in the spring and summer. There was also a carry-over effect from the first to the second cut for the highest rate of applied N in the 4th and 5th years.

Seeding dates for late-season forages. Green forage crops are suitable for late-season feeding by livestock. As the growing periods are varied, the effects of seeding dates on yields and quality of green forage crops were studied. Kale (*Brassica oleracea* L.), fodder rape (*B. napus* L.), radish (*Raphanus sativus* L.), Chinese cabbage (*B. campestris sensulato* L.), and a stubble turnip (*B. rapa* L.) hybrid were seeded at monthly intervals between late May and late August over 3 years. Kale was harvested in early November while fodder rape, radish, and turnip hybrids were targeted for harvest 60–70 days after seeding. The dry-matter yield of kale declined as the seeding dates were delayed. The primary growth of fodder rape, radish, and hybrid turnip was the same for May, June, and July seedings, but seeding in August lowered the yields by 25–38%. The in vitro dry-matter disappearance was high, ranging from 850 to 920 g kg^{-1}. The total N concentration of whole-plant tissue, leaves, stem petioles, and roots and *S*-methylcysteine sulfoxide (SMCO) concentration of whole plants increased as the seeding date was delayed. We concluded that kale should be planted by mid June for high yields. Fodder rape, radish, and hybrid turnip had similar yields with seeding from spring until mid July. In vitro dry-matter disappearance and N concentrations were high for all species.

Effects of zinc (Zn) applications on corn. The application of Zn to corn at two locations in Prince Edward Island that exhibited Zn levels of 11–14 ppm at silking failed to provide any yield responses in forage corn, although 15 ppm Zn in the leaves is often suggested as a critical level. Soil- and foliar-applied Zn increased the level of Zn in the leaves to 30–56 ppm, respectively, which is above the accepted sufficiency level. Zn applied to the leaves of corn at one location in Nova Scotia with a level of Zn in the leaves of 6–8 ppm did produce a yield response in grain corn. These data indicate that few responspectively, which is above the accepted sufficiency level. Zn applied to the leaves of corn at one location in Nova Scotia with a level of Zn in the leaves of 6–8 ppm did produce a yield response in grain corn. These data indicate that few responses to Zn applied on the farm are likely in crops grown in Prince Edward Island and Nova Scotia, since surveys of 61 corn fields in Prince Edward Island and 96 in Nova Scotia indicated average levels of 22 and 24 ppm Zn in the leaves, with no fields testing below 12 and 10 ppm Zn, respectively.

Minimum and conventional tillage and nematodes. Minimum tillage consisting of direct drilling of red clover and timothy into an existing timothy sward, and conventional tillage involving spring seeding after rototilling in fall and spring, did not differ in their effect on soil populations of stunt nematodes (*Tylenchorhynchus* spp.). In contrast, soil populations of juveniles of clover cyst nematodes (*Heterodera trifolii*) were larger in conventional tillage plots. Soil populations of root lesion nematodes (*Pratylenchus* spp.) were also larger in conventional tillage plots, but there were no significant differences in root populations between tillage regimes.

Longevity of alfalfa. In the Atlantic Region it is not always successful to maintain productive stands of alfalfa for 4 years or longer. To examine the longevity of alfalfa, physiological, morphological, and agronomic characteristics of Iroquois alfalfa seeded every spring from 1978 to 1986 were investigated. Plant density decreased with age, whereas size of crown and number of shoots increased. The dry-matter yield increased to the 3rd year but tended to decrease with age after the 4th year. The productivity of the 7-year-old plots was equivalent to that of the 2-year-old plots, but the forage from the older plots was more contaminated with weeds. The highest population of dandelion was found in the 2-year-old plots, whereas the size of each dandelion plant was larger in the older plots. The population of grass weeds increased with age, and so did the incidence and severity of crown root and root rot in alfalfa. In the seeding year the roots grew vertically to a depth of 80 cm. The root system started to spread horizontally in the 2nd year. The oldest stand, which was 8 years old, extended the deepest root, 103 cm, and developed large horizontal roots that occupied an area with a radius of 46 cm. Coldhardiness increased with age to the 3rd year but did not change after the 4th year. To increase longevity of alfalfa and productivity of old stands, research efforts have been focused on improvement of winterhardiness and pest control methods. The present study suggests a need for additional research to develop plants with horizontal roots, which optimize the area occupied by each stand, thereby minimizing the competition between alfalfa plants and increasing the plant density.

Livestock

Intensive grazing and extended-season grazing for beef production. Second-year grazing studies confirm the excellent potential of permanent pastures for beef animals and for extending the grazing season with annual pastures. Holstein steers gained 1 kg/day during the grazing pasture season. The two pasture systems produced 495 and 485 kg/ha liveweight gains for the rotational and fresh daily grazing, respectively, and also yielded 1200 and 2200 kg/ha forage dry-matter for silage. Extended season grazing from 8 October until 21 December on kale and annual ryegrass produced gains of 0.65 kg/day for the 75-day period.

POTATOES

Management and nutrition

Seed size and seed spacing for Bintje tablestock production. Bintje is a popular European yellow-fleshed cultivar that is becoming of interest in Canada. Small whole seed (average 47 g), large whole seed (120 g), and sets (55 g) cut from 110-g tubers were planted at spacings of 35, 43, and 51 cm in rows 0.9 m wide over 2 years, with the cut seed replaced by very small whole seed (37 g) in a 3rd year. Total tuber yield averaged 47 t/ha and was not affected by seed type. There were no significant interactions between seed size and spacing on tuber yields, tuber size distribution, or number of tubers. Increasing seed spacing increased yield of tubers over 52 mm from 59 to 67% of the total yield, but only reduced total yield by 2 t/ha at the 51-cm spacing. Increased spacing reduced the number of tubers from 537 000 to 462 000 tubers per hectare and increased the number of tubers over 52 mm from 35 to 41%. Large whole tubers produced the most stems (18 stems per square metre) and the highest number of tubers (558 000 per hectare) and only 58% of the yield over 52 mm. The small whole seed, the cut sets, and the very small whole seed produced similar stem densities (12 stems per square metre), number of tubers (477 000/ha), and 66% of the yield over 52 mm. Maximum production of tablestock Bintje tubers required planting 55-g cut sets or whole seed between 37–47 g at an in-row spacing of 51 cm.

In-row plant spacing for Acadia Russet potatoes. The Acadia Russet cultivar, released by Agriculture Canada's Fredericton Research Station in 1981, is gaining favor in markets requiring large tubers with a high dry matter. Yield, number of tubers, distribution of tuber size, and specific gravity were determined from plantings at in-row spacings of 20, 30, and 40 cm, in rows 0.9 m wide, over 3 years. Spacing had no effect on total yield (average 34 t/ha) or specific gravity (1.080). Increasing spacing reduced number of tuber from 302 000 to 264 000 tubers per hectare and increased the marketable yields (tubers greater than 52 mm) from 68 to 78% of the total yield. Yield of tubers greater than 68 mm (most useful in the count-pack and processing industries) increased from 6.6 t/ha at 20-cm spacing to 11.0 t/ha at 40-cm spacing.

Effect of applied fertilizer on Kennebec potato top desiccation and yield with diquat. Experiments conducted during 1979–1982 on potato (*Solanum tuberosum* L. 'Kennebec') demonstrated that excessive levels of applied nitrogen made leaf and stem desiccation with diquat (6,7-dihydrodipyrido [1,2-a:2',1'-c] pyrazinediium ion) more difficult. A split application of diquat (a.i. at 0.42 kg/ha, 5 days apart) improved leaf and stem desiccation by as much as 21 and 27%, respectively, compared with a single application with a.i. at 0.84 kg/ha. Diquat treatments had no effect on vascular discoloration. The high levels of applied nitrogen increased the yield of tubers greater than 60 mm in diameter but reduced the yield of seed-size tubers that ranged from 40 to 60 mm.

Pests and diseases

Nematode survey. Analysis of soil and root samples collected from potato fields across Prince Edward Island and the Woodstock–Grand Falls region of New Brunswick showed that *Pratylenchus* spp. were the dominant plant-parasitic nematodes. *Pratylenchus penetrans* occurred more often on Prince Edward Island, and *P. crenatus* predominated in New Brunswick. *Aphelenchoides* spp. were quite numerous in the New Brunswick samples, but this genus is not known to damage potatoes. It was estimated that only about 10% of the sites had population levels of *Pratylenchus* spp., which may have caused economic losses.

Potato diseases. In studies on potato disease control, foliar application of metalaxyl + mancozeb, oxadizyl + mancozeb, and oxadixyl + chlorothalonil on three occasions as part of a 7-day spray program to prevent disease provided acceptable control of late blight caused by *Phytophthora infestans.* Application of these treatments on a 14-day spray schedule resulted in slight increases in foliar damage by the end of the season. Several potato seed treatment fungicides (e.g. iprodione and tolclofosmethyl) improved plant stand and yields in field studies involving inoculation with *Rhizoctonia solani.* Similarly, thiophanate-methyl, mancozeb, and imazalil treatment resulted in increased plant vigor and yield and a decrease in the number of misses and weakened plants in studies on two *Fusarium* spp. and on *Verticillium albo-atrum.* Resistance to potato late blight was observed with F73008, F79055, F71086, and Libertas; Russet Burbank was again the most resistant to verticillium wilt.

HORTICULTURE

Vegetables

Broccoli cultivar evaluation trials. Results of evaluation trials conducted during three consecutive growing seasons indicate that several cultivars are suitable for production in Prince Edward Island. On the basis of yield, compactness of terminal head, and freedom from leafiness, Premium Crop and Emperor were the best of the 16 cultivars tested. Green Valiant and Green Charger produced the largest terminal heads but were rated as slightly less desirable in compactness and leafiness. Surfer also performed well. The quality of Cruiser was well within acceptable limits, but under the conditions of these trials, yield was less than that of several other cultivars.

Timing of boron (B) foliar applications on rutabaga. Two foliar applications of B at the rate of 1 kg/ha at 30 days and repeated at 42–45 days after seeding provided excellent control of brown heart in rutabaga. Similar, two-application treatments initiated 40 days after seeding or later failed to prevent brown heart at some of the seven locations where this trial was conducted over a 5-year period. Although the incidence of brown heart varied between locations, the mean incidence where no B was applied increased progressively from 30% when the roots were 5 cm in diameter to 63% at harvest. Root yields were slightly decreased by the two foliar sprays of B applied at five different stages of growth and by a single preplant soil application of 2 kg/ha.

Effect of cover crop on raspberry yields. Early-season cultivation followed by oats seeded between the rows immediately after harvest each year produced a 5-year mean yield of 6.2 t/ha. Plots cultivated throughout the growing season produced 5.8 t/ha, and those where a grass sod was maintained to within 30 cm of the centre of the row produced 4.5 t/ha.

Soil insecticides and microbial degradation. Experiments to determine the potential for soils repeatedly treated with the same or related pesticides revealed that in addition to carbofuran, aldicarb, and related carbamate-type compounds, microorganisms in one sandy loam test soil became adapted to rapidly breaking down the organophosphorus-type insecticide, chlorfenvinphos, but not isofenphos or terbufos. In previous tests, chlorfenvinphos gradually degraded in treated soils over a period of 8–12 months. However, the degrading microorganisms that developed in 1986, after 3 years of repeated annual field soil treatments, broke down the same application rate in less than 2 weeks. Succeeding laboratory treatments of the same soil resulted in a further reduction in breakdown time of 50 and 100 ppm concentrations to 3–5 days.

Tobacco

Boron and zinc nutrition of tobacco. The addition of B at 1.1 kg/ha did not increase tobacco yield. Rates of B at 8.8 kg/ha proved toxic and resulted in yield reductions. Additions of Zn tended to increase yields but not significantly. B and Zn in the tissue at levels as low as 31 and 17 mg/kg, respectively, and in the leaves (third priming) did not result in deficiency. However, it is recommended that B and Zn in tobacco be monitored periodically to detect any significant nutrient changes.

Sclerotinia stalk rot of tobacco. Sclerotinia stalk rot of tobacco has not been previously noted as a predominant disease of tobacco in Prince Edward Island. Stalks severely infected with *Sclerotinia* were weakened and could be easily broken. The disease often results in total plant loss. Leaves of infected plants were often yellowish and wilted, and not harvested. In 1985 sclerotinia stalk rot was present on approximately 1% of plants. However, severity was very low on these plants. In a 1986 survey of tobacco fields on Prince Edward Island, severity and occurrence were both substantially higher than in 1985, with at least 6% of all plants sampled infected, with a mean level of infection of 3.65 (scale of 0–10, where 0 was healthy). Several of the fields had 20% or more of plants infected, many severely. The cool, wet weather of 1986 was probably largely responsible for the increased severity of this disease.

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R.W. Jones, B.Sc., M.Sc., Ph.D.	Leader; Agronomy program, physiology and management
C.L. Ricketson, B.Sc.(Agr.), M.S., Ph.D.	Leader; Vegetable program, physiology and management
D.H. Webster, B.Sc., M.Sc., Ph.D.	Soils management and nutrition
A.V. Rodd, M.Sc.	Soils management

Crop Protection

K.I.N. Jensen, B.Sc., M.Sc., Ph.D.	Head of Section; Weed physiology
M.G. Anderson, B.Sc., Ph.D.	Vegetable storage and cereal diseases
S.O. Gaul, B.Sc., M.Sc.	Toxicology
J.M. Hardman, B.Sc., M.Sc., D.I.C., Ph.D.	Insect ecology, orchard pests
P.D. Hildebrand, B.Sc., Ph.D.	Berry crops and vegetable diseases
E.R. Kimball, B.Sc.	Residue chemistry
C.L. Lockhart, B.Sc.(Agr.), M.Sc.	Berry crops and vegetable diseases
W.T.A. Neilson, B.Sc., M.Sc.	Blueberry insects
N.L. Nickerson, B.Sc., M.Sc., Ph.D.	Berry crop diseases
M.T.H. Ragab, B.Sc., M.Sc., Ph.D.	Residue chemistry
K.H. Sanford, B.Sc.(Agr.), M.Sc.	Integrated control of orchard insects
H.B. Specht, B.Sc.(Agr.), M.Sc., Ph.D.	Field crops and vegetable insects

Food Processing

R. Stark, B.Sc., Ph.D.	Head of Section and Program Leader; Food science
E.D. Jackson, B.Tech, M.Sc., Ph.D.	Food microbiology
R.F. Kelly, B.Sc.	Food technology
R.A. Lawrence, B.Sc. (Chem.Eng.), M.Sc.	Food engineering
T.M. Smith, B.Sc.	Food technology

Fruit and Vegetable Storage

P.D. Lidster, B.Sc., M.Sc., Ph.D.	Head of Section and Program Leader; Fruit storage physiology

Poultry

H.W. Hulan, B.Sc.(Agr.), M.Sc., Ph.D.	Head of Section and Program Leader; Nutrition and physiology
F.G. Proudfoot, B.Sc.(Agr.), M.Sc.	Physiology and management

Nappan Experimental Farm, Nappan, N.S.

F.W. Calder, B.Sc.(Agr.), M.Sc.	Superintendent; Forage crops
A.E. Foster	Administrative Officer
N.R. Fulton, B.Sc.(Agr.)	Sheep management and nutrition
L.F. Laflamme, B.Sc.(Agr.), M.Sc., Ph.D.	Ruminant nutrition
R. Troelstra, B.Sc.(Agr.)	Beef management and nutrition
T.A. Van Lunen, B.Sc.(Agr.), M.Sc.	Swine management and nutrition

Departures

J.M. Burrows, B.Sc.(Ag.Eng.) Resigned, 13 June 1986	Food engineering
J.E. Langille, B.Sc.(Agr.) Retired 30 June 1986	Agronomy, cereal and forage crops
P.A. Poapst, B.Sc.(Agr.) Retired 20 December 1986	Vegetable storage physiology

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[1] Seconded from Marketing and Economics Branch.

[2] Seconded from Libraries Division, Corporate Management Branch.

[3] Seconded from Systems and Consulting Directorate, Corporate Management Branch.

INTRODUCTION

The Kentville Research Station conducts a comprehensive research and development program, which is focused on the horticultural, poultry, and winter cereal sectors of the agricultural industry in Atlantic Canada. The research is multidisciplinary and encompasses genetic improvement, nutrition, and management as well as the protection of economic crops from insects, diseases, and weeds. Increasing emphasis is being placed on the research and development needs of the food processing industry through development of new products as well as improvements in process technology. The extension of the effective marketing season for domestic fruit and vegetable produce is also being stressed through innovative storage research. Management of livestock and their related feed crop requirements are studied extensively at the Nappan Experimental Farm. Emphasis is on the beef cow–calf, sheep, and swine production systems.

The research results reported herein are intended to provide an overview of current studies and progress achieved. More complete information may be obtained in the annual research reports of the two establishments as well as by writing to the Research Station, Agriculture Canada, Kentville, N.S. B4N 1J5, Tel. (902) 678-2171; or the Experimental Farm, Nappan, N.S. B0L 1C0, Tel. (902) 667-3826.

G. M. Weaver
Director

BREEDING, NUTRITION, AND CULTURE OF CROPS

Lowbush blueberries

Lowbush blueberry yield at various spacings. The lowbush blueberry cultivars Augusta, Brunswick, Chignecto, and 510 were harvested for the first time following a sprout season that had been preceded by three consecutive harvests. Unfortunately, a spring frost reduced the yield from all cultivars by approximately 50%. However, marketable yield from plants at the single-row spacing was equal to or greater than the yield from plants in double- or triple-row spacings. Results from the 1984 harvest were similar and indicate that although the total yield from the double- and triple-row spacings may be slightly higher than those from the single-row spacing, it is questionable at this point whether the higher return would pay for the increased costs of plant material at planting.

Effect of nitrogen and herbicide on lowbush blueberries. Growth habit and yield of lowbush blueberries were studied at three locations for response to nitrogen and herbicide applications. Nitrogen in the form of urea (N at 40 kg/ha) applied with the herbicide hexazinone (3 kg/ha) increased the length of stems at one location but not at the others. At all locations, the incidence of branched stems increased in response to nitrogen or hexazinone applications, whereas the degree of branching increased with nitrogen only. The mean number of flower buds per stem was not affected by nitrogen but increased with hexazinone. Nitrogen had no significant effect on yield at one location, but reduced yield at the other locations. Hexazinone also had no effect on yield at one location where there were few weeds, but increased yield at locations with higher weed populations.

Lowbush blueberry evaluation. Lowbush blueberry selections and cultivars planted in 1978 (27 clones), 1980 (63 clones), 1981 (81 clones), and 1983 (16 clones) were harvested in 1986. The highest yielding were clone 633, with 11.0 t/ha in the 1978 trial; clone 607, with 8.6 t/ha in the 1980 trial; clone 73-21, with 10.5 t/ha in the 1981 trial; and clone 69-1, with 1.1 t/ha in the 1983 trial. The average weight of 25 berries for these clones was 12.0 g, 8.5 g, 16.0 g, and 18.0 g, respectively. Consistently good performance was achieved by cultivars Blomidon and Chignecto and clones 510 and 69-1. Clones 510 and 69-1 are currently under consideration for introduction as cultivars.

Raspberries

Raspberry breeding. Six raspberry seedlings were selected for further evaluation from 1625 seedlings derived from 25 crosses, bringing the 1985–1986 selection total to 24. The crosses yielding the most selections were

Pocahontas × K69-4 and K77-10 × K77-9. Thirty-seven raspberry hybridizations were performed in 1986 encompassing sources of large fruit size (Titan, Royalty, K81-6), good fruit quality (K81-2), winterhardiness (Festival), and resistance to late yellow rust (Nova). A cultivar trial was established at Kentville including cultivar Festival and selections K74-1, K81-6, K82-2, K82-3, and K85-3.

Strawberries

Strawberry breeding. Thirty-two strawberry seedlings were selected for further testing from 4300 seedlings that had been screened for resistance to *Phytophthora fragariae* Hickman before planting in 1985. Thirteen of these selections have shown some degree of the everbearing habit. Five selections, with cultivar Arking as maternal parent, were selected for their exceptional fruit firmness. Selections K83-1, K83-2, K83-3, and K83-4, all resistant to red stele, continued to perform well in observational trials. These midseason selections will be established in regional cultivar trials and grower trials in 1987.

ORNAMENTALS

Light, vegetative growth and flowering of Gypsophila paniculata. Young plants of *Gypsophila* grown for various time periods in controlled environment chambers at either 8.8 mol/m^2 per day high photosynthetically active radiation (HPAR 400–700 nm) or 3.2 mol/m^2 per day low photosynthetically active radiation (LPAR) reached visible flower-bud stage at different times, depending in part on the cumulative irradiance. Plants were transferred at 14-day intervals from HPAR to LPAR chambers and vice versa. Flower buds were formed first on plants that received between 500 and 550 mol/m^2 during the first 76 days in treatment. Thereafter, buds were initiated within 8–10 days irrespective of cumulative photosynthetically active radiation (PAR). Yield of flowers and vegetative plant parts increased with cumulative PAR up to about 745 mol/m^2 received over a 115-day period. Higher irradiances during early development were most effective in improving yield. The results support the use of supplemental lighting applied to plants before transplant to stimulate flower yield and to allow scheduling of this crop.

Eastern regional plant-testing network. A fifth site (St. John's, Nfld.) was added to the network in 1986. Five-year trials were completed on 32 taxa of woody shrubs, trees, and ground covers. New taxa were added at all trial sites. Commercial propagation of superior material for the Atlantic Region, identified over several years, is proceeding. Full trial reports are available.

System for precise root temperature control in recirculating nutrient systems. A simple and inexpensive system for control of root temperature in nutrient film culture was designed and successfully tested. The system currently operates in four controlled environment chambers but is also suitable for greenhouse use. Each chamber incorporates four independent nutrient-flow systems, each served by a separate solution reservoir incorporating a cooling coil and a 500-W stainless steel heater. A single, refrigerated water bath circulates cooled water through the coils, which are linked in parallel. Each heater is linked to a controller based on a silicone-controlled rectifier, triggered by the output from a bead thermistor in the solution reservoir. Solution temperature control of ±0.5°C can be achieved with this system.

The influence of light- and dark-period temperatures and root temperatures on growth of lettuce in recirculating nutrient-flow systems. Butterhead lettuce (cultivar Montana) was grown in recirculating nutrient solution culture in growth chambers under various combinations of day air temperature (TD; 12, 15, 19.5, or 22.5°C), night air temperature (TN; 5 or 14°C), and root-zone temperature (TR; 20, 23, 26, or 29°C). Photosynthetic photon flux was 3.8 mol/m^2 per day. Following 28 days in treatments, there were no significant interaction effects of TD and TN. Increasing TD from 12 to 19.5°C increased fresh- and dry-leaf weight and leaf area at final harvest, but increasing TN from 5 to 14°C had limited effect. Specific leaf area and leaf area ratio increased with TD and TN. Leaf weight ratio increased with TD but remained constant with TN. The overall effect of TR on plant size was minor. Dry weight of roots decreased with increasing TR, but fresh- and dry-leaf weight was not affected. Leaf area increased with TR up to 26°C. Increases in TR resulted in increased values for specific leaf area, leaf-area ratio, and leaf-weight ratio. The results suggest that some butterhead lettuce cultivars may be grown efficiently under low daily photosynthetic photon flux (PPF) integrals by allowing dark-period air temperatures to decline to 5°C while maintaining approximately 19°C during the light period. In the cultivar Montana, increasing TR above 20°C under those conditions had little beneficial effect on plant size at harvest.

VEGETABLES

Comparison of a commercial fertilizer (17-17-17) with three fish waste products applied to four transplanted vegetables. Commercial fertilizer was compared with three fish waste products: pelleted fish silage, liquid fish silage, and fish bone meal. Marketable yields of broccoli and Brussels sprouts were significantly higher from plants supplied with the commercial fertilizer with N applied at 150 kg/ha preplant than from plants receiving a similar rate of the fish waste products. However, marketable yields of cabbage and cauliflower from plots supplied with the commercial fertilizer were similar to yields from plots supplied with pelleted fish silage. Marketable yield for all four vegetables supplied with liquid fish silage was equal to the yield from plants supplied with fish bone meal.

Effects of phosphorus (P) rate and placement applied to vegetables growing in soil with a high level of phosphorus. Transplants of broccoli, Brussels sprouts, cabbage, and cauliflower received P at 0, 11, and 22 kg/ha applied either broadcast preplant with N and K or banded singly at transplanting. All banded P treatments received N and K broadcast preplant at recommended rates. Marketable yields of broccoli, cabbage, and cauliflower were not significantly affected by P rate or placement. However, marketable yield of Brussels sprouts receiving P broadcast preplant was significantly higher ($P < 0.05$) than the yield from plants receiving P banded at transplanting. Rate of P application had no effect on yield of sprouts. The recommended P rate for a soil testing at this high level of P is 22 kg/ha. However, this initial experiment tends to show that the O rate supplies sufficient P to these four vegetables.

Fruit set of tomatoes grown in row tunnels. Fruit set of Springset was improved in 1986 when the first two to three flower clusters were sprayed with chlorophenoxyacetic acid or when plants were shaken briefly every 1–2 days, compared with fruit set of plants that had the same type of row tunnel but that were not sprayed or shaken. Yields of ripe fruit to 25 August were 22.2 and 16.8 t/ha, respectively, for the sprayed and shaken plots compared with 5.1 t/ha for check plots.

Multiple plants in direct-seeded broccoli production. Results obtained in 1986 with direct-seeded Premium Crop broccoli, when two or three plants were allowed to grow together at plant by row spacings of 30 × 60, 37.5 × 75, and 45 × 90 cm, were essentially identical to those obtained with transplanted broccoli as reported previously. At a row spacing of 37.5 × 75 cm, the two and three plants yielded 10 and 8% higher than single plants, respectively. At 45 × 90 cm, they yielded 13.5 and 21.9% higher, respectively. Yields of multiple plants at these spacings were similar to the yield of single plants at a row spacing of 30 × 60 cm. The multiple-plant system for direct-seeded broccoli offers several commercial advantages over single plants, including high yields at relatively wide spacings, full plant stands without hand thinning, and adaptability to existing equipment.

Multiple plants per transplant unit for broccoli production. With the cultivar Premium Crop, the use of two or three plants per transplant unit gave yields about 20% higher than those of single plants at a plant by row spacing of 37.5 × 75 cm. At 45 × 90 cm, the use of two or three plants per unit gave yields 15–30% higher than single plants. At both of these spacings, multiple plants gave yields as high as those of single plants spaced 30 × 60 cm. The savings in number of transplant units needed at 37.5 × 75 cm and 45 × 90 cm compared with 30 × 60 cm are 47 and 67%, respectively. Multiple plants performed well with both Kord 809 cells, with a volume of 53 cm^3 per cell, and Plastomer 200 cells, with a volume of 29 cm^3 per cell. These 1986 results were similar to those obtained in previous years.

Favorable results with the use of multiple plants were also obtained with the cultivars Septal, Southern Comet, Green Comet, Green Valiant, and Kayak. Little response was noted for Green Hornet and Green Duke in 1986.

Plastics for advancing maturity of carrots. Cultivars responded differently in the effects of Agplast and Reemay commercial row covers on early marketable yields. With Allseasons and Cellobunch, Agplast and Reemay gave 17.6 and 10.4% higher yields, respectively, than the 22 t/ha yield of uncovered check plots on 22 July. Row covers did not increase early yields of Caropak appreciably. Allseasons was the most productive cultivar and seems well suited to early production with plastics.

Vegetable cultivar evaluation. Trials included 521 cultivars of the following crops: asparagus, broccoli, Brussels sprouts, cabbage, carrots, cauliflower, cucumbers (slicing), lettuce, onions (Spanish and dry), parsnips, peas (freezers), and tomatoes. Reports for each crop are available.

CEREALS

Overwintering nitrate reductase activity in wheat. Application of fall N [as NH_4NO_3 or $Ca(NO_3)_2$] in November to various winter wheat cultivars in the Annapolis Valley resulted in a rise of in vivo nitrate reductase activity. The rise was proportionately much larger for the activity determined without assay NO_3, indicating an increase in in situ substrate levels. However, the ratio $-NO_3$ / $+NO_3$ nitrate reductase activities declined (from about 0.3) with the approach of winter, and remained low (about 0.1) and similar to unfertilized treatments through the overwintering phase. This indicated that homeostatic mechanisms rendered the wheat crop indifferent to previous NO_3 exposure. The results apparently prevent the possibility of loading winter wheat leaf tissue with storage NO_3 in the fall. A relationship was found whereby the ratio of the two activities for a range of cultivars occurred in the sequence Borden > Absolvent > Monopol > Trillium, corresponding to the winterhardiness order of these cultivars in the Maritime Provinces. It is therefore possible that low cytoplasmic levels of NO_3, which will determine the rates of nitrate reduction in the absence of exogenous assay NO_3, are somehow related to winterhardiness.

Late nitrogen application and grain protein. Application of N at 50 kg/ha as granular NH_4NO_3 to the winter wheat cultivars Monopol and Ural increased grain protein about 1%, was indifferent to timing between mid-boot and anthesis growth stages, and was without effect on yield in 1986. Nitrate reductase levels in the flag leaf increased very little in response to N, and showed little increase in substrate NO_3 compared with the flag's potential to respond to NO_3 in in vitro incubations. It therefore appears that much of the flag leaf's potential to process NO_3 remained unused with N fertilizer applications to the soil surface.

FORAGES

Effect of weathering on large round bales of hay. A field of grass-legume hay was harvested and stored as large round bales (LRB) for up to 300 days under various conditions. The hay stored inside remained in very good condition and did not lose its quality. The dry hay stored in plastic bags underwent minor changes, but the quality remained excellent. The bales left outside alone, in single rows or in double rows, lost a major part of their nutritional value especially in the first 15 cm from the outside of the bale. The important and the uniform amount of precipitation that is observed in our area dictates that LRB should not be wintered outside and unsheltered. The quality losses are very large and make this harvesting technique uneconomical unless some form of protection is used.

TREE FRUITS

Tissue culture of apple rootstocks. Establishment procedures with dormant scions, actively growing shoot tips (spring and summer), and excised meristems from newly developed leaf buds were evaluated. Establishment was most efficient with actively growing shoot tips from either field or greenhouse. Certain rootstocks tended to produce considerable callus upon establishment. Formulations that will reduce this and improve proliferation efficiency for the 32 rootstocks now in culture are being studied.

International apple rootstock trial. Kentville Research Station is one of the sites currently evaluating a number of apple rootstocks in a cooperative trial with the International Dwarf Fruit Tree Association. These trials are located in apple-growing regions throughout North America. Homogeneous lots of Starkrimson Red Delicious on the select list of apple rootstocks were propagated at one nursery and distributed to cooperators in the spring of 1984.

Terminal growth in 1985 at Kentville correlated with tree size resulted in the following: the clones Budagovsky 491, P22, CG10, and MAC 39 fell in the small category; Budagovsky 9, EMLA 26, M.4, EMLA 7, and Domestic Seedling in the medium category; and CG 24, P1, and MAC 1 in the large.

Novaspy apple released. Novaspy apple was released, a new apple that combines high quality for both fresh and processed markets, long storage life, and scab resistance. It resulted from a cross of Nova Easygro × N.Y. 44411-1 (Red Spy × Golden Delicious), and although it has many characteristics similar to Spy, Novaspy is more precocious in bearing and has more highly colored fruit.

Nova sweet cherry released. Nova sweet cherry was released, a midseason sweet cherry of the Lambert type with good-sized dark red fruit of good flavor and moderate resistance to cracking and brown rot. The tree is moderately vigorous, and consistency of cropping has been above average under marginal conditions for winter survival.

PROTECTION OF CROPS AGAINST PESTS

Insect pests

Dimethoate sprays applied to sprout fields prevent maggot infestation in adjacent crop fields. One or two sprays of dimethoate, at 500 mL/ha, applied to sprout (noncrop) lowbush blueberry fields, prevented infestations of blueberry maggot in adjacent crop fields. The first spray was applied 2–5 days after the first adult capture on Pherocon AM traps and the second, if applied, 20 days later. The sprays were applied with an automatic mist concentrate sprayer equipped with a micronair head and mounted on a tractor power take-off. The results of these tests suggest that it may be feasible to develop control programs for the blueberry maggot that require only spraying on noncrop fields. Present recommendations require one or two sprays of dimethoate, azinphos-methyl, or phosmet applied on crop fields to prevent maggot infestations.

Simulating infestations of the European red mite (ERM) in Nova Scotia apple orchards. A computer model developed by Dr. Dan Johnson of the Lethbridge Research Station to simulate ERM in British Columbia apple orchards was adjusted to simulate ERM infestations in Nova Scotia orchards. Biological differences between ERM in Nova Scotia and the British Columbia race described in the original model required the use of new parameters based on life table studies of Nova Scotia populations. After modification the model was able to generate patterns of density and age structure similar to those observed both in orchard plots treated with miticide and in plots that had no miticide treatment. The model can now be used to refine tactics of miticide use in apple orchards and is being expanded to describe the influence of pesticides both on ERM and its principal predator, the phytoseiid mite *Typhlodromus pyri* Scheuten.

Plant pathology

Control of anthracnose of highbush blueberry. Four applications of anilazine with active ingredient (a.i.) at 180 g/100 L significantly reduced the incidence of berries with anthracnose caused by the fungus *Colletotrichum gloeosporioides* Penzig. Captan and several sterol-inhibiting fungicides failed to control the disease.

Control of Hypericum perforatum with a host-specific Colletotrichum gloeosporioides. A survey of Nova Scotia blueberry fields indicated that *C. gloeosporioides* Penzig occurs widely and often provides a high level of natural control under field conditions. Studies under controlled conditions demonstrated that *C. gloeosporioides* could infect and control *H. perforatum* L. under a wide range of temperatures and leaf-wetness periods. When inoculated with mycelium or spore suspensions, none of a range of crop species tested developed disease symptoms, although the native *Hypericum canadense* did. *C. gloesporioides* may have potential in the biological control of this weed elsewhere.

Inoculating indicator clones with Phytophthora fragariae for race identification. Races of *Phytophthora fragariae* Hickman, the fungus that causes red stele disease of strawberries, are identified by their ability to infect a series of indicator clones. In tests with the indicator Blakemore, drenching the soil around potted plants with zoospore suspensions gave more uniform infection than various methods of inoculation with mycelial preparations. The main disadvantage of using zoospores as inoculum was the variability in zoospore production among various isolates of *P. fragariae*. This problem could be overcome to some extent by manipulating the age of the stock cultures used for zoospore production.

Raspberry late yellow rust. Late yellow rust of raspberries, caused by *Pucciniastrum americanum* (Farl.) Arth., affected up to 70% of the fruit and 90% of the leaves in commercial red raspberry plantings in Nova Scotia in 1986. Aeciospores were released from white spruce (the alternative host) during a 3- to 4-week period from mid June to early July. Pathogenicity tests indicated that the uredinial stage of the fungus recycles on raspberries. Most fruit infections appeared to be caused by urediniospores produced on raspberries earlier in the season. The cultivar Festival was highly susceptible to rust, but Nova remained nearly free of uredinia even in areas where other cultivars were severely rusted. Control of late yellow rust in the Atlantic Provinces may be possible through appropriately timed fungicide applications or the use of resistant cultivars, or both.

Symptoms and cause of broccoli head rot. Head rot of broccoli is a major constraint to production of this crop in the Atlantic Provinces. Surveys of diseased crops during 1985 and 1986 indicated that rot was caused primarily by bacteria. Early disease symptoms appeared as water soaking in areas on heads where water droplets from rain had remained for more than 48 h. Small black lesions associated with stomata developed on flowerets, followed by a soft decay that spread during prolonged wet periods. In all fields where bacterial rot developed, a fluorescent pseudomonad was consistently isolated and identified as *Pseudomonas marginalis* (Brown) Stev. Healthy, nonwounded broccoli heads that were inoculated with isolates of *P. marginalis* developed typical symptoms of head rot. The disease surveys indicated that two closely related fungi, *Alternaria brassicicola* (Schw.) Wiltshire and *A. brassicae* (Berk.) Sacc., were also pathogenic to broccoli. Disease symptoms initially appeared on flowerets as small, dry black lesions, which later expanded as the pathogens sporulated, but symptoms remained localized. Losses caused by fungal decay, however, were not considered to be economically important.

Pesticide chemistry – weeds

Clopyralid – a promising herbicide for strawberries. In greenhouse studies, Kent and Veestar strawberries were more tolerant of clopyralid than of equal rates (0.1–0.5 kg/ha) of dicamba and 2,4-D. The main effects at the highest rates were reduction in runner initiation and malformation of newly formed daughter plants. In the field, clopyralid at 0.1–0.4 kg/ha applied at renovation caused little significant injury to the same cultivars. In other trials, such hard-to-control weeds as tufted vetch and goldenrod were satisfactorily controlled by 0.2 kg/ha clopyralid.

Persistence of metribuzin, trifluralin, and diphenamid in soils under plastic covers. Metribuzin (0.5 kg/ha preemergence), diphenamid (6.0 kg/ha preemergence), and trifluralin (0.75 kg/ha preplant incorporated) were shown to provide safe and effective weed control in tomatoes grown with a clear plastic surface mulch and row tunnel. Analysis of soil samples from plots with or without the plastic covers indicated that residual levels of the three herbicides were significantly higher on covered plots than on uncovered ones 1, 2, and 4 months after application.

Selective fall treatments for brush control in blueberries. The interval of time between the early senescence and abscision of harvested lowbush blueberry foliage and that of some woody weeds offered a period in which 2,4-D (0.2% w/v), dicamba (0.1% w/v), and a mixture of the two could be applied with little or no crop damage and with good control. Applications during the first 3 weeks of October provided selective control of speckled alder, trailing blackberry, bayberry, sweet-fern, and bearberry.

STORAGE AND PROCESSING

Apples

Application of membrane technology to juice processing. The juice of apples (McIntosh) and pears (mixed) was concentrated using a reverse osmosis concentrator with 200 molecular weight cut-off, spiral-wound membranes. Tests were conducted varying the inlet pressure, feed rate, percentage of recycled material, and the brix of the concentrate. The feed, permeate, and concentrate were analyzed for color, haze, pH, percentage of titratable acidity, percentage of soluble solids, sucrose, glucose, fructose, and head space aromas. The energy consumption of the system was monitored to enable a comparison with evaporative concentrators.

Clarification tests were conducted on the same unit in an ultrafiltration mode. Apple and pear juice was clarified using 20 000 and 50 000 molecular weight cut-off spiral-wound membranes. The system proved very effective in clarifying, although difficulties were encountered in the irreversible fouling of the membranes, particularly with juice with no enzyme pretreatment.

Apple quality in response to sequential low-oxygen and standard controlled atmospheres. McIntosh apples stored initially in 1.0–1.5% CO_2 plus 1.0% O_2 at 3°C were more firm than fruit stored initially in 4.5–5.0% CO_2 plus 3.0% O_2 at 3°C, indicating that early exposure to low O suppressed the subsequent rate of softening in standard controlled atmospheres. The initial exposure period in low oxygen needed to induce retention of apple firmness depended on cultivar and temperature. For McIntosh, Spartan, and Golden Delicious cultivars, respectively, maximum poststorage fruit firmness was reached after 7.5, 4.5, and 1.5 months initial exposure to low oxygen at 0°C and after 4.5, 3.0, and 3.0 months at 3°C. Poststorage evolution of CO_2 and C_2H_4 generally decreased with continuing storage in low oxygen, but the severity of senescent disorders and the incidence of low oxygen injury increased. Poststorage headspace ethanol evolution increased with exposure to 1.0% O_2 in McIntosh apples stored at 0°C, and Spartan apples held at either 0 or 3°C.

Effects of supplemental phosphate sprays on quality and storage disorders of McIntosh apple. In 2 years of testing, phosphate compounds [$NH_4H_2PO_4$, KH_2PO_4, and $CaH_4(PO_4)_2$ in 1982; $HN_4H_2PO_4$ in 1983], applied to McIntosh apple trees as six foliar sprays at weekly intervals starting 4 weeks after bloom, increased leaf and fruit P, decreased loss of firmness under some storage conditions, and decreased incidence of low-temperature storage disorders. Phosphate sprays improved firmness retention of apples stored in either 5% CO_2 plus 3% O_2 or 0.7% CO_2 plus 1% O_2 in 1982 and maintained fruit firmness during a simulated shelf life at 20°C for apples stored at 0°C. Firmness retention at 20°C of the 1983 crop was improved by monobasic ammonium phosphate regardless of storage temperature. Apple samples from unsprayed control trees had mean phosphorus concentrations of 85.4 and 94.4 ppm fresh weight in 1982 and 1983, respectively (whole fruit less seeds and stems).

Internal atmosphere of apples in response to differentially permeable fruit coatings. An initial study indicated that the chitin-based fruit coating Nutri Save® significantly increased internal carbon dioxide and decreased internal oxygen atmospheres in the carpel cavity of apples. The film formed by application of 1.5% (wt/vol) solution, by fruit immersion at harvest and subsequent storage at 0°C, resulted in carbon dioxide levels of 3–4% CO_2 plus oxygen levels of 7–9% O_2 as compared with 0.5–1.5% CO_2 plus oxygen levels of 17–20% O_2 for uncoated apples. The content of carbon dioxide and oxygen in carpel cavities of fruit removed from 0°C storage and held at 20°C and high humidity for 3 days was approximately 6–10% CO_2 plus 4.5–6% O_2 for treated apples as compared with 4.0–6% CO_2 plus 9–17% O_2 in the untreated controls. Reducing humidity at shelf temperatures (20°C) to less than 80% relative humidity (RH) further increased carbon dioxide and decreased oxygen levels in the carpel cavities. After a 7-day simulated shelf test at 20°C, fruit firmness of Spartan apples treated with Nutri Save® were approximately 9 N (newtons; 0.9 kg force) greater than the untreated control.

Berry crop

Development of frozen fruit bars. Frozen fruit bars were reformulated to contain lower quantities of fruit puree in an effort to eliminate gumminess in the finished product. Fruit juice and whole fruit or pieces were substituted for the puree. Taste panels were conducted on several blueberry and strawberry bars. The products containing whole berries or pieces, or both, were the least acceptable, whereas those containing juice and small amounts (less than 20%) of puree fared somewhat better. Strawberry bars received slightly higher scores than their blueberry counterparts.

Preliminary formulas were established for cranberry and apple frozen bars. Both required extensive preparation before freezing, and the end products were deemed unsuitable because of high acid content (cranberry) or lackluster flavor (apple).

Vegetables

Development of deep-fried vegetable chips. Dehydrated vegetable material proved unsuitable as a base for deep-fried vegetable chips; therefore, open-kettle and vacuum frying of vegetable slices (carrots and parsnips) were reevaluated. Under vacuum, excellent results were obtained when vegetables were deep-fried (120°C oil) for 5–6 min. The most favorable open-kettle products were vegetables deep-fried in 160°C oil for 2–3 min. Texture was slightly more acceptable in the open-kettle product and shrinkage was negligible, whereas color and flavor retention were superior in the vacuum-fried products.

A consumer panel on vacuum-fried chips resulted in a 75% positive response for carrots and 63% for parsnips. Several enquiries have been received from the private sector regarding commercialization of the work. However, no firm commitments have been made to warrant continuation of the project.

Flavor analysis of cabbage and other Brassica vegetables. Difficulty was experienced in discerning subtle differences in the intensity of peppery flavor of creamy coleslaw by sensory analysis, necessitating application of chemical techniques to measure isothiocyanates and related compounds. An adequate methodology was developed for the quantitation and qualitation of isothiocyanates and related compounds. Gas chromatography using a DB (dura bond) wax capillary column with a flame ionization detector (FID) and gas chromatography–mass spectrometry (GC–MS) (Finnigan Mat. ITDS) proved suitable. In addition, the potential for high-performance liquid chromatography methods for quantitation of *Brassica* flavor components will be evaluated and correlated with GC–MS data if such methods prove promising. Studies to determine the effects of food processing on the enzymatic hydrolysis of glucosinolates present in cabbage to yield different types and abnormal amounts of natural flavorings will be continued and extended to comparisons between fresh and stored cabbage and possibly to other cole crops such as broccoli or Brussels sprouts.

ANIMAL SCIENCE

Beef

Feeding beef cows according to body condition. Beef cows of thin or moderate body condition were fed to gain a total of 30, 60, or 90 kg during late pregnancy. Our 2-year study pointed out that body condition and precalving nutrition had little effect on calf weight and survival rate. However, our results indicated that calf weaning weights and pregnancy rates of the cows were markedly reduced by a poor body condition at parturition. These results also suggest that the cow will protect the fetus during pregnancy by allowing her reserves to be depleted but will take care of her personal needs after parturition.

Feeding time influences time of calving. Beef cows have a tendency to calve within the 8-h period following feeding. A study using 72 pregnant cows of various body condition and nutrition levels demonstrated that 50% of cows do calve in that interval if they are fed a single daily meal for at least 2 weeks before the expected calving day. The relationship was not affected by any other parameter measured. This conclusion was also evident for beef cows fed at 8:00 a.m., 4:00 p.m., or 10:00 p.m. Data are not available for cows fed more than one meal or those given less time to adjust to a new feeding schedule.

Pigs

Crab meal for pigs. An evaluation of crab meal as a protein source for pigs has determined that it can be an acceptable alternative to conventional protein sources. Pigs were fed from 0 to 15% crab meal in the diet (from 20 to 100 kg) in grower and finisher diets. The results indicate that pigs perform well when fed 5% crab meal, whereas a slight growth depression is observed at higher levels. High levels of crab meal appear to improve carcass quality.

High-moisture corn for pigs. Recent work at Nappan has shown that high-moisture corn can be stored in low-cost storage facilities and fed to pigs in on-farm mixing. Results of the test indicate that pigs fed a simple diet of high-moisture corn, soybean meal, and a vitamin–mineral supplement perform as well as those fed conventional feed mixes.

Hull-less oats for pigs. An experiment was recently completed to determine the optimum level of hull-less oats to be fed to growing–finishing pigs. Hull-less oats grow well in Atlantic Canada and are high in both available protein and digestible energy. The study determined that pigs fed a simple diet made up of hull-less oats with a vitamin–mineral–amino acid supplement provided superior growth performance and feed conversion as compared with conventional feeds. There was some indication that hull-less oats may negatively affect carcass quality.

Steamed potato peel for pigs. Four experiments were conducted to evaluate the performance of pigs fed various levels of steamed potato peel. This product is waste material from the manufacture of French fries and represents a low-cost alternative to conventional energy sources in the diet. The project determined that 30% of the diet on a dry-matter basis can be made up of the potato product. It was also determined that young pigs do not require an adjustment period before high levels can be fed. Many pork producers in New Brunswick have been using steamed peel since the results of this project were released. Plants in New Brunswick produce enough steamed peel to feed 70 000 pigs at 30% of the diet.

Poultry

A pneumatic device for attaching wing bands to day-old chicks. A device for attaching aluminum bands to the wings of day-old chicks is described and illustrated. It is powered with compressed air and utilizes both hand- and foot-operated controls. Using this device, an operator can apply wing bands without an assistant at rates up to 300 chicks per hour.

The nutritive value of wheat screenings as a feed ingredient for adult Leghorn hens. Nine hundred and twenty Leghorn hens were used in two experiments designed to evaluate the effects of feeding adult diets containing ground wheat screenings at 0, 15, 30, 45, and 60% of diets that were calculated to be isoenergic and isonitrogeneous. Results from both experiments reveal that there were no significant ($P > 0.05$) dietary effects for mortality, egg production, egg specific gravity, egg Haugh units, or body weight. The higher dietary levels of wheat screenings were associated with a significant ($P < 0.05$) linear depression in feed efficiency. In experiment 2, hens fed the diet with 60% wheat screenings were significantly delayed in reaching a 50% rate of egg production and laid eggs that, at 182 days of age, weighed significantly less than eggs laid by hens fed diets with lower levels of wheat screenings; but as these results did not occur in experiment 1, the effects on sexual maturity and egg weight are inconclusive. It can be stated that layer diets may contain up to 45% wheat screenings without the expectation of a depression in biological performance.

Effects of various totals and ratios of dietary calcium and phosphorus on the performance and incidence of leg abnormalities in male broiler chickens derived from normal and dwarf maternal genotypes. A factorial experiment with day-old Hubbard male broiler chicks (702 each from normal and dwarf maternal genotypes) assessed the effects of three levels of total calcium (Ca) and available phosphorus (aP) at three different ratios (Ca:aP) during the starter (0–21 days) and finisher (22–40 days) periods. General performance was assessed as well as tibia characteristics (strength, ash, Ca, P), serum parameters (alkaline phosphatase, Ca, P, Na, K, Cl), and leg abnormalities – tibial dyschondroplasia (TD), twisted legs, and erosion of femoral head. Nine starter and nine finisher diets were matched with percentages of Ca and aP ranging as follows: 0.95–1.45 and 0.41–0.73 for the starters; and 1.00–1.43 and 0.31–0.51 for the finishers, respectively. Increasing the total Ca + aP to 2.00 and 1.81 and the Ca-to-aP ratio of 2.65 and 3.55 for starter and finisher, respectively, reduced ($P < 0.05$) TD and other leg abnormalities but resulted in the poorest biological response. Ca levels at 1.02–1.11% and 1.05–1.14%, and aP levels at 0.47–0.63% and 0.35–0.46% for starters and finishers, respectively, supported the best biological performance. Higher levels of Ca (1.27–1.37%) during both the starter and finisher periods resulted in a lower (< 0.05) incidence of TD and other leg abnormalities but poorer biological performance, particularly for the heavier normal genotype. Significant interactions of genotype × dietary regimen occurred for virtually every measured trait, indicating that these two genotypes (normal and dwarf) are metabolically different.

The performance of one normal and two dwarf meat maternal genotypes and their progeny as affected by rearing and adult dietary treatments. The performances of one normal and two dwarf meat maternal genotypes were compared in a factorial experiment designed to estimate the combined effects of feeding two juvenile diets – low protein (LP), high energy (HE) versus high protein (HP), low energy (LE) – from 106 to 140 days and four adult dietary treatments (LPHE, HPHE, HPLE, and an HPLE excluding canola meal) fed from 141 to 420 days. The performance of the three genotypes differed significantly ($P < 0.05$) for egg production, egg fertility at 322 days, feed efficiency, live-body weights, and monetary returns less the cost of chicks and feed. One of the dwarf genotypes exhibited the highest monetary returns. Juvenile dietary treatments had no significant ($P < 0.05$) effect on the traits measured except age at sexual maturity and female body weights at 154 days. Several traits were affected by the adult dietary treatments including mortality, incidence of fatty liver syndrome, hen-day egg production, feed efficiency up to 322 and 420 days, and live-body weights. Mortality resulting from fatty liver syndrome was significantly ($P < 0.01$) lower among hens fed the HPLE diet without canola meal compared with hens fed the other three adult diets, all of which included canola meal as a feed ingredient.

The nutritive value of ground rye as a feed ingredient for adult Leghorn hens. One thousand and eighty Leghorn hens were used to evaluate the effects of feeding ground rye from 140 to 490 days at 0, 5, 10, 15, 20, and 25% of diets. Traits that exhibited dietary effects were hen-day egg production, sexual maturity, body weight, and feed efficiency. The higher dietary levels of ground rye had an adverse effect on egg production and feed efficiency.

Effect of altering the cation–anion (Na + K – Cl) and calcium content of the diet on general performance and incidence of tibial dyschondroplasia of broiler chickens housed in batteries. A factorial experiment was conducted using a total of 200 day-old Hubbard chicks housed in wire floor batteries to assess the interacting effects of two or three levels of dietary sodium (Na), potassium (K), and chlorine (Cl); at two levels of calcium (Ca); as well as one level of available phosphorus (P) (0.50%) on the performance, wetness of droppings, and incidence of tibial dyschondroplasia (TD). For Ca at 0.95%, Na (0.17 and 0.30%) × K (0.80, 1.10, and 1.40%) × Cl (0.22 and 0.44%) were present in all combinations; for Ca at 1.38% the levels (except for K, 0.80 and 1.40%) and combinations were the same. The various cation–anion combinations produced 12 and 8 different milliequivalents per kilogram of Na + K – Cl at 0.95 and 1.38%, respectively. The effects of Ca, Na, and Cl on growth were interdependent as evidenced by the significant Ca × Na and Ca × Na × Cl interactions; increasing Cl at low Ca–low Na resulted in an improvement, whereas increasing Cl at either high Ca or high Na resulted in a substantial reduction in growth. Except for Ca-reduced feed utilization among birds fed high versus low Ca during 0–21 days, there were no main effects for this trait nor were there any interactions observed between cations and anions for feed utilization. Increasing either dietary Na or K increased the fecal moisture significantly (Na, $P < 0.01$; K, $P < 0.001$), but the magnitude of the effect was greater for K than for Na. The incidence of TD increased ($P < 0.01$) with increased dietary Cl. Effects of Ca, Na, and K on TD were interdependent as evidenced by the Ca × Na × K ($P < 0.05$), pointing to the importance of dietary electrolyte balance in determining the development of TD among broiler chickens.

Effects of glutaraldehyde-surfactant solution on hatchability of hens' eggs. A series of four experiments involving a total of 7300 hatching eggs laid by meat parent genotypes were used to estimate the effect on hatchability of immersing eggs in a glutaraldehyde solution. Although genotypic effects on hatchability were demonstrated, immersion in the glutaraldehyde solution had no significant ($P > 0.05$) adverse effect on hatchability.

The amino acid and mineral composition of white fish meal containing enzyme-digested and untreated stickwater solids. Two representative commercial white fish meal samples were used to study the effect of added enzyme-digested (FMED) or untreated (FMR) stickwater solids on their protein quality. They contained the same amino acids in approximately similar proportions. The main advantage of the enzymatic digestion of stickwater solids is that the product becomes more soluble and less viscous, thus reducing build-up on the interior of the evaporators and dryers, and that it improves the recovery of fish proteins from the press liquor. The crude protein content of FMED (64.2%) was comparable to that of FMR (61.6%), estimated by the Kjeldahl nitrogen method, but these figures were higher than their true protein contents as determined by quantitative amino acid analysis. Although the total lipid content (6.0%) of FMED differs from that of FMR (3.41%), their apparent metabolizable energies were similar. Determination of 5-hydroxylysine as an index of collagen indicated that FMED and FMR contained 33.5 and 33.3% collagen, respectively.

Effects of modified conventional and reverse-protein rearing dietary regimens on the performance of Leghorn hens. Two commercial Leghorn genotypes were used to study the effects of rearing dietary treatments on juvenile mortality, growth, and adult performance. One control, two modified conventional, and three reverse-protein juvenile dietary regimens were compared. The two genotypes differed in egg production, age at 50% egg production, egg weight, egg specific gravity, Haugh units, and monetary returns. There was no evidence of any interaction between genotype and dietary treatment. Juvenile dietary treatments had a significant ($P < 0.05$) effect on body weights at 21 days of age that continued through the juvenile and adult periods to 490 days. Age at 50% egg production, feed efficiency, and initial egg weights were also affected. Although hens reared on one of the modified conventional and two of the reverse-protein regimens returned 53¢ per bird more than the remaining three rearing dietary regimens, this difference was not significant ($P > 0.05$). Evidence is provided that reverse-protein juvenile dietary regimens may support adult performance that equals or surpasses the performance of birds reared on conventional dietary programs.

Sheep

Maedi-visna. Results of establishing a flock free of maedi-visna by removing ewe lambs at birth and raising them artificially in an isolated barn look promising. Ewes have continued to test negative for the viruses since they were first removed in March of 1984. Final assessment of the program cannot be made until 1988. The time in which the ewes develop the specific antibodies to the viruses is variable. The age of the experimental farm flock ranges from 7 months to 7 years, with the majority of ewes becoming positive reactors for the viruses at 3 years of age. The flock at Nappan consists of negative-testing sheep and their offspring, which are tested at 6-month intervals.

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INTRODUCTION

The Fredericton Research Station conducts a comprehensive research program on potato breeding, potato pest management, animal and crops, engineering, horticulture, and soils. Research at the Hervé J. Michaud Experimental Farm is concentrated on the horticulture of the southeast coastal region of New Brunswick. Experiments include cultivar and management trials on vegetables, berry and tree fruits, and cereals and forage crops.

The potato breeding program at Fredericton, which is the centre for the national breeding program, is focused on producing improved parental lines that can pass to their progeny a superior ability for French fries and potato chips, as well as for the fresh-market crop; in addition, ancient Andean varieties and the germ plasm of wild species are used to create parents with higher levels of resistance to diseases. Research in the Potato Pest Management Section includes the identification and management of potato diseases; antiserum production and the development of serological methods for viral and bacterial disease detection; and the development of disease-forecasting models. Insect research includes ecology and control of potato pests and the evaluation of the effectiveness of insecticides and insect–plant interactions.

Animal and crop research is directed toward the nutrition and management of dairy and beef cattle. Researchers at Fredericton also evaluate cereal, forage, and corn cultivars to make more efficient use of locally produced feeds. Under the agri-food economic regional development agreement (ERDA), a program for developing technology that focuses on livestock feed, livestock industry, and horticulture has been undertaken.

Soil research emphasizes finding solutions to soil-related problems in the region and is aimed at improving the agricultural land base. Research is directed toward the development of technology to improve drainage and prevent soil erosion. Horticulture research involves the evaluation of apple and strawberry cultivars and the management of those crops including studies on winterhardiness. The Agricultural Engineering Section deals with the improvement and development of machinery related to agriculture and on-farm storage of produce.

The results herein reported provide an overview of continuing research programs. More complete information can be obtained from the Research Station, Agriculture Canada, P.O. Box 20280, Fredericton, N.B. E3B 4Z7; Tel. (506) 452-3260.

G. C. Misener
Acting Director

POTATO BREEDING

Variety development. Under a new format for the introduction of varieties, two potato selections have recently been released exclusively to organizations in the private sector. F74123 has already been named Donna, and F73008 is to be named Brador. Brador has smooth, oblong, yellow-fleshed tubers, an extremely high level of resistance to late blight in both foliage and tubers, and late maturity.

Three selections with second early sizing and maturity characteristics are in the final stages of evaluation. F70021 produces a high set of bright, white-skinned, white-fleshed tubers. It has resistance to potato virus Y (PVY), potato leaf roll virus (PLRV), and *Verticillium albo-atrum* and moderate resistance to *Fusarium sambucinum*, *F. coeruleum*, and rhizoctonia. F72090 has round-oval, white-fleshed tubers. It has resistance to PVY, moderate resistance to common scab, and some resistance to rhizoctonia. The round-oval, white-fleshed tubers of F75040 retain their attractive appearance well in storage. F75040 has the best quality of these three selections; it also has resistance to golden rematode and moderate resistance to common scab and PVY.

In replicated maincrop yield trials conducted at four locations in the region, 19 Fredericton selections were evaluated. Several of these produced promising scores for French fries and potato chips. Four selections were evaluated in the early yield trial.

In 1986, 16 and 20 entries were evaluated in trials of material for potato chips in Nova Scotia and New Brunswick, respectively.

These included named varieties and advanced selections from Fredericton and several breeding programs in the United States. A majority of the entries equaled or exceeded Norchip in scores for potato chips.

Under a cooperative project with the United States for the breeding and evaluation of new potato clones for the northeast (NE-107), 31 entries were evaluated in a trial in New Brunswick. These included 13 tussets. This trial continues to provide a valuable association with breeding programs in the northeast United States.

Application of bedding plant technology to potato breeding. The potato breeding group raises approximately 50 000–80 000 seedlings from true seed annually. Since the seedling generation is raised in the greenhouse, several recent developments in the bedding plant industry have been successfully adapted to potato seedlings. The growing medium has been changed from a soil-based medium to an artificial (peat-moss based) medium.

The 10-cm diameter clay pots have been replaced by standard 1020 plastic flats, which hold 18 potato seedlings each (planted in individual packs). This container system in turn is filled mechanically with a soil mixer – flat filler. A plug system into which a vacuum seeder is incorporated is currently being perfected in its application to planting potatoes from true seed mechanically and with a high level of precision. A limited number of seedlings (±15 000) can now also be grown outdoors as a result of the adaptation of this type of technology. A rolling bench system, yet to be installed in one of the greenhouses, will increase the capacity of that particular greenhouse by 25%. As a result of these innovations, the size of the annual seedling production could be maintained, in spite of the 33% reduction in greenhouse space as well as substantial reductions in the labor force.

Multi-trait selection in an Andigena breeding population. Data obtained from an Andigena breeding population were used to compare various strategies for multi-trait selection. Analyses were carried out to estimate heritabilities and genetic correlations of six quantitative traits.

This information was then used to compare the efficiency of various selection strategies for the traits. Correlated responses to indirect selection has efficiencies ranging from zero to about 60% of the response to direct selection of individual traits. Multi-trait index selection by means of a suitable system showed varied genetic gains, which ranged from small (specific gravity) to moderate (maturity, stolon persistence, tuber yield) to high (tuber number and tuber weight) when compared with gains obtained from direct selection for the individual traits. It appears that index selection could be used for selecting optimum genotypes in the population.

The genetic consequence of 2n gametes in 4×-2× crosses. The genetic consequence of 2*n* gametes produced by the diploid hybrid in the progenies of tetraploid–diploid crosses was investigated on a theoretical basis. The 2*n* gametes are produced by the diploid either through first (FDR) or second (SDR) division restitution during meiosis. Comparison was made between corresponding 4×-2× and 4×-4× crosses with respect to differences in genotypic frequencies, means, and variances of a quantitative trait of the progenies. It was concluded that the position of a heterozygous locus in the chromosome influences the relative merit of FDR and SDR gametes in the 4×-2× crosses. FDR gametes are expected to give the trait higher means and lower variances in the progenies of 4×-2× crosses than those of 4×-4× crosses under the dominance model for genic effect when a locus is located close to the centromere of a chromosome. SDR gametes demonstrate such effects only when heterozygous loci are distributed toward the end of chromosomes. The critical point in the chromosome that divides the effects of the two types of 2*n* gametes is where the rate of double reduction is one-seventh for the tetraploids and that of single exchange tetrads is two-thirds for the diploids. FDR gametes appear to be more capable of showing the effects than SDR gametes when heterozygous loci are randomly distributed along the entire length of the chromosomes. Neither FDR nor SDR gametes are expected to produce maximum heterotic effect for the 4× progenies in 4×-2× crosses.

Evaluation of parental lines for reaction to Fusarium dry rot. During the past 2 years, 40 parental lines that had not been evaluated previously for reaction to *Fusarium* dry rot were tested using Boyd's method. The replicated test entries plus six cultivars as checks were inoculated with a condial suspension of either *F. sambucinum* or *F. coeruleum* at two sites midway down each tuber using a modified syringe. Following 6 weeks' incubation at 12°C, the tubers were cut across both inoculation sites and rated for the extent of disease progression. Under these conditions, Acadia Russet, F68061, Hudson Red Beauty, Shepody, and 96-56 exhibited moderate resistance to *F. sambucinum*, whereas Acadia Russet, Bake King, Serrana, and Shepody displayed moderate resistance to *F. coeruleum*. The remaining entries fell between the moderately to extremely susceptible categories. This information will assist in determining cross combinations so as to reduce the likelihood of obtaining extremely susceptible progeny from susceptible × susceptible crosses.

POTATO PEST MANAGEMENT

Purification of viroid by high-performance gel permeation chromatography. High-performance liquid chromatography (HPLC) with gel permeation was used to purify potato spindle tuber viroid (PSTV) from a crude nucleic acid extract of plants. The method requires less than 6 h from homogenization of tissue to the elution of the pure viroid fraction. Using a TSKG 4000 SWG column, the viroid was well resolved from DNA, and 5S and 4S RNA species. The HPLC system also proved suitable for separating circular and linear forms of PSTV. The procedure was rapid, and the pure viroid obtained was infectious. Although the time required to complete identification of the viroid fraction is rapid, this method is not recommended for routine testing of PSTV.

New disease symptoms in field-grown potato and higher virus concentration inmixed infection of PSTV and PVY. PSTV and PVY were isolated from plants of the cultivar Kennebec with severe necrotic symptoms in the field. Thirteen additional potato cultivars were tested in the greenhouse for this synergistic reaction, and eight developed necrotic responses similar to the cultivar Kennebec. PVY concentration was significantly higher in doubly infected plants, compared with those infected with PVY alone. There was no concentration change for PSTV in the mixed infection. The concentration of PVY in dual-infected plants was higher regardless of the type of symptoms (i.e., necrotic or mosaic). Although PSTV has been eliminated from the New Brunswick seed and processing crop, in some countries the different symptoms of mixed infection could cause problems in controlling the disease.

Relationship of virus concentration with the field resistance to PVY in potatoes. The concentration of PVY expressed as enzyme-linked immunosorbent assay (ELISA) value (A_{405} nm) was determined in 26 potato cultivars grown in the field and in the greenhouse. On the basis of virus concentration, potato cultivars belonging to group A, B, and C (grouping proposed by Bagnall and Tai 1986) did not differ significantly and constituted the most susceptible group, whereas those of group D and E differed significantly with each other and with group A, B, and C and constituted moderate and highly resistant groups, respectively. In the 2nd year of infection, virus concentration was higher in each group, irrespective of resistance level. Thus, the infected plants of resistant groups, in the 2nd year of growth, could be as rich sources of virus to aphids as are plants from susceptible groups. It appears that cultivars with mosaic symptoms have a higher virus concentration than those with necrotic symptoms.

Field resistance to PVY and to PLRV assessed by cluster analysis. Forty potato cultivars, exposed to infection with PVY in field trials (1972–1983) were split into five groups by means of the Scott-Knot cluster analysis procedure: *A* (most susceptible) to *E* (most resistant). Thirty-six cultivars, exposed to infection with PLRV in separate trials (1972–1981), were similarly split into four groups: *A* to *D*. By comparison with these standards, additional cultivars and many seedlings, present in the trials for 4–8 of the years, could be classified. Although we used the common PVY^O strain, our ratings of a number of European cultivars followed closely those given in official Dutch cultivar lists, based on the new PVY^N strain. The PLRV ratings were also quite similar. The relative performance of susceptible and resistant cultivars, submitted by commercial growers to the New Brunswick–Florida test, indicates that the reservoir of both PVY and PLRV could be reduced drastically – if not eliminated – by exclusive use of resistant cultivars. The resistance must first be incorporated into cultivars acceptable to the processing trade. Progress has been made, but displacement of widely grown cultivars susceptible to PVY and PLRV, such as Russet Burbank, represents a formidable challenge to potato breeders.

Detection of bacterial ring rot by DNA hybridization. Thirteen widely divergent isolates of *Corynebacterium sepedonicum* were screened for the presence of a 31 Mdalton (45.5 kb) plasmid, and all but two were shown to harbor the plasmid at a level of about 30 copies per cell. Cleavage of the purified plasmid with restriction enzymes ClaI, EcoRV, and PstI gave an identical and unique banding pattern in agarose gels for each enzyme in all plasmid-carrying isolates. Preliminary results from southern blotting experiments supported the conclusion that the plasmid is homologous in all isolates of the bacterium. A 1.4 Mdalton fragment from PstI digests of the plasmid has been isolated and labelled with radioisotope by nick translation; its usefulness as biotin-labelled probe for the detection of the ring rot pathogen is currently being evaluated.

Colorado potato beetle (CPB): Resistance to insecticides. Field studies undertaken in 1982 had established the presence of a limited number of populations of CPB resistant to the insecticide carbofuran in New Brunswick. Baseline data on the contact toxicity of seven insecticides to a susceptible and a resistant population of CPB to carbofuran were collected in 1985. The resistant strain showed 37-fold levels of resistance to phosmet and low-level (< 10-fold) resistance to permethrin, fenvalerate, disulfoton, and aldicarb. This strain is 43 times more resistant to carbofuran than the susceptible one. Both strains of beetles were found resistant to endosulfan. This finding is probably related to previous, extensive use of cyclodiene insecticides. These data will help with the monitoring of the evolution of insecticide resistance in populations of CPB in future years.

Flight periodicity of potato aphids. The respective flight periodicities and temperature thresholds determine to a large extent the establishment and dispersal of insect pests in crops. On potatoes, they play an important role in determining the importance of various aphid species as vectors of plant diseases. Field and laboratory studies determined these factors for the three important potato colonizing aphid species in North America.

The diurnal periodicity was found to be unimodal for *Myzus persicae* (Sulzer) and *Aphis nasturtii* (Kaltenbach) and bimodal for *Macrosiphum euphorbiae* (Thomas). Temperature thresholds for flight takeoff from potato plants under field conditions are 16°C for *M. euphorbiae*, 16–17°C for *M. persicae*, and 19°C for *A. nasturtii*. The teneral period lasts for 24 h for *M. persicae* and *A. nasturtii* but takes 24–48 h for *M. euphorbiae* alienicolae.

The effects of bromoethane (BE) and ethanol (ETOH) on potato (Solanum tuberosum) tuber sprouting and subsequent yield responses. BE has demonstrated a reliable ability to reduce significantly the duration of dormancy in the major cultivars produced in New Brunswick. Consequently, the effects of BE on tuber production were studied under field conditions using recently harvested basic nuclear stock greenhouse tubers that were dormant. Since previous studies have shown that ETOH can promote sprouting in a wide range of species and may be of value as a low-toxicity additive in the current application, the present experiment included an evaluation of multiple BE treatments as well as the effects of ETOH applied simultaneously as a vapor for a 24-h period at room temperature. Treated tubers of the cultivars Kennebec, Russet Burbank, and Katahdin began to emerge within 4 weeks, although there was very significant interaction ($P < 0.01$) between cultivar and treatment effects in terms of mean number of sprouts per tuber and time to 50% emergence. Similar trends were evident in tuber number, total tuber yield, and the number of grade A and B seed tubers. For example, Kennebec responded most effectively to BE–BE + ETOH in most recorded responses, whereas Katahdin responded very effectively to one treatment of BE. Two consecutive BE treatments gave the best overall result when the responses for all cultivars were compared. The present study shows that BE is effective in breaking dormancy immediately, and ETOH vapor can enhance the promotive effects of BE in a cultivar-specific manner. The superior biological, chemical, and cost characteristics of BE compared with rindite as well as the similarity in effectiveness for dormancy breaking indicate that BE could be beneficially incorporated into various seed multiplication programs.

Wild potato trichome constituents. The foliage of a number of wild potato species is covered with glandular trichomes (type A and type B) that utilize mucilaginous secretions to entrap or dissuade potential predators. There is also evidence to suggest that the secretions may inhibit the growth of harmful microorganisms. In investigations involving the exudate from the type B glandular trichomes of *Solanum berthaultii* Hawkes accessions, the major nonvolatile components were in some cases found to be 3,4,6-tri-*O*-acylated sucrose esters and in others, 3,3,4,6-tetra-*O*-acylated sucrose esters. The latter compounds are the first naturally occurring sucrose esters shown to contain acyl substituents on both the glucose and fructose moieties. A kindred class of compounds, namely 2,3,3,4-tetra-*O*-acylated sucrose esters, have subsequently been identified in the type B glandular trichomes of *Solanum neocardenassii* Hawkes and Hjerting. A knowledge of these sucrose ester structures, in addition to furthering understanding of natural pest-control processes, provides a valuable monitoring tool for breeding programs aimed at developing related pest-resistant domestic varieties. The distinctive nature of the various sucrose esters will also provide new taxonomic markers for establishing relationships past and present within the *Solanum* genus.

Tuberlet size influences survival. Leaf-bud cuttings are used in several potato nuclear stock multiplication schemes. We designed experiments to determine if the size of the tuberlets from leaf-bud cuttings (minitubers) had any influence on the subsequent survival and vigor of plants from these small tubers. Leaf-bud cuttings were exposed to suitable day lengths in greenhouse and growth cabinets. The resulting leaf-bud tuberlets were harvested after senescence of the leaf-bud cuttings and placed in plastic bags for refrigeration (approximately 4°C) for 4 months. The tuberlets were removed from refrigeration, graded by weight, and placed in groups of similar weight (0.1–3.8 g). For all cultivars tested (Caribe, Jemseg, Katahdin, Kennebec, Savle, Sebago, Shepody, Red Pontiac, and Russet Burbank) the percentage of tuberlets that survived, as indicated by sprouting, declined as the tuberlets became smaller. We assumed that 50% survival would be the minimum tolerable for propagation purposes, and thus the average minimum weight for 50% survival in these trials was 1 g. Vigor was measured as the height of the greenhouse plants from tuberlets 4 weeks after planting and was found to be in direct proportion to the initial weight of tuberlets. It is important, therefore, to find ways to optimize the size of leaf-bud tuberlets used for propagation.

ANIMALS AND CROPS

Crab meal protein supplements for beef cattle. Some of the waste from the processing of crabs and lobsters in New Brunswick is dried, ground, and sold as an organic fertilizer or as feed for livestock. It has a high content of ash (about 50%) and chitin (about 20%) because it contains the shell. As currently produced, the product is variable in true protein content but averages about 25% with less than 2% lipids. The digestibility of the crude protein by sheep is 70%. Most of the mineral in the shell is calcium carbonate, and laboratory determination of rates of reactivity with acid indicates that crab meat should be a useful source of buffers for ruminant animals. Studies using nylon bags with fistulated cows showed that the crude protein was degraded in the rumen relatively slowly, suggesting the meal would be a useful supplement to use with high nonprotein nitrogen feeds such as silage.

Several feeding trials were carried out with growing beef cattle to evaluate the use of crab meal as a protein supplement. The initial results were disappointing. Although the addition of conventional protein supplements such as soybean meal generally improved total feed intake and rates of gain, the addition of crab meal did not, and in some cases it even appeared to depress gains compared with those obtained with the unsupplemented basal diet. Laboratory studies did not reveal the presence of any toxins that might be injurious to the animal or to rumen microbes. When the supplement containing the crab meal was pelleted, excellent intake and growth rates, comparable to those with soybean meal, were obtained. It was concluded that the taste or odor of the crab meal was inhibiting intake. The intake problem probably was exacerbated by the use of individual plywood feeding boxes with high sides, which tended to confine the odors.

Effects of crab meal on metabolic activity of rumen bacteria. In vitro metabolism studies were carried out with rumen microorganisms to determine if crab meal (CM) might contain factors toxic to the microorganisms, which could explain the poor animal performance, described above, when beef cattle were fed mash type supplements containing CM. Two series of trials were conducted. In the first trial, dry matter, nutrient detergent fiber, and in vitro cell wall digestibility (IVCWD) were determined on six ratios of CM and timothy;

0:100, 20:80, 40:60, 60:40, 80:20, and 100:0. No toxic effect on the metabolic activity of the microflora was observed. Secondly, trials using dilutions of the original level of microflora showed no evidence of inhibitory effects of CM. All samples of CM examined were without thiaminase activity; however, samples had thiobarbituric acid values (>2.0), which would suggest rancidity of meat products. Results from this study indicate that CM does not impair normal rumen microbial function. The work was carried out by the New Brunswick Research and Productivity Council under contract to Agriculture Canada.

High-protein opportunity feeds. By-products from the production of cash food crops can make useful high-protein feeds. Two examples, "bypassed" peas and canola screenings, were compared in a feeding trial with growing beef cattle. Bypassed peas are peas contracted for freezing or canning that have become too mature for their intended purpose and are left to ripen on the vine. The canola screenings were from a crop grown in Nova Scotia for export. The peas or canola screenings were incorporated into the supplement fed to beef cattle receiving corn silage and were compared with soybean meal and with the unsupplemented ration. All the protein supplements produced increased gains compared with the unsupplemented diet, but none of the differences were statistically significant. The cattle fed the canola screenings gained slightly less than those fed peas or soybean meal and consumed significantly less feed ($P < 0.01$). As a result, the canola-fed steers had a better rate of feed conversion. This reflects the high level of oil in the canola screenings. It was concluded that both bypassed peas and canola screenings produced in the Maritime Provinces are satisfactory protein supplements for beef cattle fed corn silage.

Metabolism in developing rumen epithelium. Rumen epithelial tissue from calves fed conventional diets and weaned at 28 days of age or fed only milk up to 60 days of age were examined for the specific activities of 17 enzymes that represent a substantial cross section of normal mammalian metabolism.

At birth the specific activities of the epithelial enzymes that metabolize dietary glucose were high, but they decreased with age. The specific activities of the enzymes from milk-fed calves were approximately the same as the conventionally fed group, indicating that changes in carbohydrate metabolic capabilities were related to the age of the animal.

The rumen is a rapidly growing organ in the young calf. The availability of triglycerides as a cell wall constituent and NADPH as a source of energy for cellular anabolic processes can be constraints to tissue growth.

Much of the α-glycerol-phosphate backbone for triglyceride synthesis in newborn and milk-fed calves is probably derived from the glycerol liberated from metabolism of dietary butterfat and from activation (phosphorylation) by glycerokinase. In weaned calves, glycerokinase activity is much lower; however, at this time there is no butterfat in the diet. The activity of α-glycerophosphate dehydrogenase is increased in the weaned calves, encouraging the diversion of glycolytic intermediates as required.

In the young growing calf, NADPH production was shown by high levels of glucose-6-phosphate dehydrogenase and isocitrate dehydrogenase. In mature cows and milk-fed calves, the levels of both enzymes were much lower. Thus, diet or factors stimulating rumen growth were probably the primary determinants of the specific activities of these enzymes.

Long-term effects of timothy fertilization. Timothy remains the major forage grass species grown in Atlantic Canada. A series of plots set up in 1960 on a Riverbank sandy loam to investigate the long-term effects of N, P, and K on the yield, persistence, and nutrient content of timothy are still carried on. Ammonium nitrate (N at 0, 90, 180, 270 kg/ha), superphosphate (P_2O_5 at 0, 34, 68, 102 kg/ha), and muriate of potash (K_2O at 0, 56, 112, 168 kg/ha) are applied annually. Phosphorus, potassium, and half of each nitrogen treatment are applied in early spring, with the remainder of the nitrogen applied after the first crop is harvested. Two crops are harvested annually at the full-head stage.

Results from this experiment published in 1966 showed the importance of the N–K relationship in terms of both yield and survival of timothy. Dry-matter yields of 8.5 t/ha were reported. Twenty years later (1985–1986), a 2-year average dry-matter yield of 7.2 t/ha composed of 80% timothy was obtained when 180, 68, and 168 kg/ha of N, P_2O_5, and K_2O were applied. The relatively low crude protein content (9.2% at first cut and 12.0% at second cut) is explained partly by the soil pH (5.4) and the late cutting date. Dry-matter yields ranged from 1.0 to 6.5 t/ha in 1985 and from 1.6 to 7.9 t/ha in 1986. The N–P and P–K relationships were important in terms of yield. Botanical composition changed drastically over the years. Low P and K fertilization resulted in the predominance of *Agrostis* spp. Phosphorus and potassium fertilization without nitrogen led to a sward containing about 10% clovers. The timothy stand was maintained only in plots receiving a proper balance of N, P, and K fertilizers.

These results emphasize the importance of a proper N–P–K balance in a timothy fertility program aimed at obtaining long-term productivity.

Dynamics of forage quality. Profiles of the changes in nutritive quality of forages during their primary growth phase were prepared from 6 years of observation (1980–1985). Samples of forages were taken weekly from 25 May to 22 July to cover the growth stages from vegetative to seed formation. Because of annual weather variation, the dates when certain maturity stages were observed covered a range of up to 10 days. Early-maturing grasses exhibited the greatest variation in rate of development between years. The average daily decline in in vitro digestibility (IVD) of eight cultivars of timothy was 0.57% per day ($n = 203$, $r^2 = 0.86$) and of crude protein content, 0.23% per day ($r^2 = 0.77$). The rates of decline (percentage per day) of IVD of bromegrass was 0.36; of orchard grass, 0.70; and of reed canarygrass, 0.54. Legumes declined in IVD and protein content more slowly than most of the grasses. The average decline (percentage per day) of four red clover cultivars in IVD was 0.38 ($n = 70$, $r^2 = 0.86$) and of crude protein content, 0.19. Alfalfa cultivars tended to retain their nutritive quality longer, with the IVD declining by 0.30% per day and the crude protein content by 0.10% per day. These profiles provide a basis for assessing and predicting the progress of plant development and changes in nutritive quality in response to climatic variation.

Cereal crops: nitrogen fertilization. Four barley varieties (Leger, Laurier, Volla, and Rodeo) were grown at five nitrogen levels with and without the application of the plant growth regulator cerone. General results are from a 2-year study in Grand Falls. Fertility treatments had little effect on plant height but higher nitrogen application increased lodging. Fertility treatments of N at 50 kg/ha at seeding plus 50 kg/ha at Zadoks stage 30, and N at 50 kg/ha at seeding plus 100 kg of N at Zadoks stage 30 resulted in the highest yields. High fertility (N at 100 kg/ha) at seeding increased proliferation of tillers and resulted in lower yields. Increasing fertility resulted in a gradual trend of decreasing the 1000 kernel weight and the weight per hectoliter.

Application of the plant growth regulator cerone decreased height and lodging, and increased yield. Cerone had the negative effect of reducing the 1000 kernel weight and the weight per hectoliter of all varieties in the test. Protein analysis for 1986 is not complete, but 1985 trends indicate an increase in grain protein with each increase in nitrogen application. Application of Cerone also appears to increase grain protein.

Seeding rates. Two barley varieties, Leger and Volla, were grown at six seeding rates (100–600 plants per square metre) at two fertility levels. Increasing seeding rates increased establishment and the number of heads per square metre, although the tillering ratio was decreased. There were more heads per square metre at higher densities, but heads were smaller, with fewer kernels per head. Increasing plot density decreased plant height while increasing lodging. There were no differences in yields over the seeding rate of 200 plants per square meter. There was little variation resulting from seeding rate in 1000 kernel weight and weight per hectoliter. Increasing the fertility had little effect on yield and yield components over the six seeding rates. The 1986 protein analysis is not yet available, but trends from 1985 indicate little effect on grain protein resulting from seeding rate but an increase in percentage of protein resulting from increased fertility.

A mechanical clean-out system for a silage compactor. Research to verify the value of silage additives has been difficult with upright silos because of the large number of silos needed to replicate treatments. A JR 700 Ag-Bag silage compactor is being used at the Fredericton Research Station to store 10–20 t of silage in plastic bags, making it possible to simulate commercial conditions with relatively small quantities of forage and thus to replicate treatments. Over 1 t of forage may remain in the tunnel of the silage compactor when a bag is filled and ready to close. When using the machine for research on ensiling methods, this material is weighed, treated, and must be put into the bag or removed and accurately weighed. A mechanical system has been designed and tested for moving the forage from the tunnel into the bag. A wall was fabricated to fit inside the tunnel of the compactor. When a bag is completed, two hydraulic cylinders powered by the tractor hydraulics swing the wall through the tunnel moving the forage into the bag. The use of this system reduced the time and labor required to close a bag and nearly doubled the number of experimental lots that can be made per day.

ENGINEERING, HORTICULTURE, AND SOILS

The effect of stone windrowing on potato harvesting. The concept of stone and clod windrowing before the planting of potatoes and its effect on harvesting were investigated. The destoning operation is completed by a machinery system manufactured in Europe. Stones and clods are separated from the soil and conveyed to a trench by a windrower. The trench, in which the stones and clods are placed, is previously formed between pairs of ridges by a furrow opener. The quantity of stones and clods transferred was measured in several fields in New Brunswick. Dimensional characteristics of the ridges before and after planting were also determined. During harvesting, a comparison of tuber injury and harvester forward speed was made between the conventional growing system and the stone-free system.

Results from the study indicated that when comparing the two-row harvesting and the windrowing, plus four-row harvesting, the level of damage caused to potatoes was significantly less with the destoned system than with the conventional system.

A model to facilitate farm machinery use and cost data collection. A machinery model was developed that facilitates the collecting and summarizing of operational data related to farm machinery use. Application of the model to the Fredericton Research Station has exemplified the usefulness of this approach to the farm management.

In the development of the model the main goal was to minimize the machine operator's time used for data recording. The resulting data log for recording machine activities can be completed quickly by the operator. A separate log is maintained for each tractor and self-propelled machine. All other machines are attached to a power unit, and their use is recorded in the respective tractor log. The operator records each task and its actual starting and finishing time as well as the tractor metered time.

Separate records are used for repair costs of each machine, whereas fuel and oil consumption figures are recorded on the tractor or power unit file. The tasks performed can be coded to a commodity crop such as potatoes in order that machine use and costs can be divided among various crops. At the Fredericton Research Station the activities are assigned to livestock feed, horticulture, or farm maintenance. The program operates on an IBM Model 3081 computer. Three tables that summarize machine use and operating costs over specified periods of time are available from the program. The first table lists the tasks performed and by which tractor and includes the hours and frequency that each tractor is used for individual tasks. The second table presents the hours of use, fuel consumption, labor, and resulting costs for each motorized vehicle. A summary of the various tasks performed and their costs is given in the third table. The tables can be prepared for any given time span by selecting the start and end dates of the period.

Production of crude starch from a rod mill. A rod mill with steel rods was used to crush and grind potatoes into starch and cellulose fibers. The objective was to release the starch particles while leaving the cell wall material unshredded so that a simple sieving process could provide a crude-starch product suitable for shipping to a central location for final cleaning and processing. The minimum practical steel-rod diameter was 18.75 mm, with 38 placed in a drum 460 mm long by 350 mm in diameter rotating at 40 rpm. When the retention time in the rod mill increased from 4 to 16 min the percentage of dry matter retained in the larger screens (above 180 mm) dropped from 41 to 19%, whereas the product passing through the small screens (104 mm) increased from 51 to 81%. During the same period the fine material (smaller than 44 mm) increased from 29.5 to 34.5% of the total. This component change most probably represents excessive processing of the starch granular. Although the grinding process is simple, quite complex recycling systems might be necessary to prevent excessive grinding of the starch particles. If this could be avoided, a suitable combination of rod diameters and lengths could be selected to grind whole tubers to give a crude-starch solid product containing greater than 95% starch at 50% moisture content.

Rooting of cultured Kentville Station clone (KSC) apple material. In cooperation with the Kentville Research Station, we investigated improving the rooting of tissue-cultured shoots of winter-hardy KSC apple rootstocks. The use of a specific rooting culture medium, prior to transplantation to an intermittent mist system and shade cloth, enhanced rooting and survival. Furthermore, a 7-day dark treatment followed by a 7-day light treatment, while the cultured shoots were in rooting medium, improved rooting considerably. Direct rooting and hormone-soaking treatments were extremely deleterious to the shoots. Splitting the stems of the shoots longitudinally increased rooting in some clones. Careful attention to the type of shoot produced in vitro (mature, rosette type or immature, scalelike leafed type) increased the survival and time-to-root of the propagules – especially if the shoots were stressed while rooting. Shoot cultures of apples rooted more easily after they had been cultured for more than 8 months. Considerable clonal differences in the reponse of the KSC material to rooting regimes was observed.

Mulches for improved overwintering of strawberries. Marketable yields from Veestar strawberry plants protected with various winter mulch materials were variable after two moderate winters with adequate to good snow cover. In 1986, the best yield was 14 041 kg/ha from the treatment using clear polyethylene under half the recommended rate of straw (4.5 t/ha), followed by thermal blanket (microfoam) and the unmulched control. Straw at 9 t/ha (recommended rate) produced less marketable fruit than those previously mentioned but more than in treatments of 10 cm of wood shavings, 2.5 cm of sawdust, or 5 cm of wood shavings. The least productive plots were those unmulched and kept clear of snow throughout the winter. In the plots kept clear of snow, symptoms of winter injury were present in early spring, and marketable yields were about one-third of the best treatments at 3755 kg/ha. Date of first harvest for treatments of straw over clear polyethylene and thermal blanket were 6 days ahead of recommended straw and 10 days ahead of the treatment of 10-cm wood shavings.

Strawberry cultivar performance. During the past 3 years of testing the cultivars Kent and Glooscap have been outstanding. In 1986, marketable yields were generally good from all cultivars tested, with Glooscap outperforming all others with a yield of 29 206 kg/ha. This yield was slightly better than that of Kent and Kentville selection K80-15. Fruit size and other characteristics of all three were good, with K80-15 holding promise for fresh-market shipping. Other cultivars compared in the order of marketable yields were Honeoye, Redcoat, Bounty, Micmac, and K81-12.

Improving tree performance of apple nursery. The Somerford Sheltatree,® when placed around individual, grafted apple trees in the nursery, increased tree terminal growth by 25% in 1985 and 85% in 1986. Average terminal growth of trees without guards was 61.25 cm in 1985 and 19.6 cm in 1986, whereas growth of trees grown in the brown-colored ultraviolet-stabilized corrugated polypropylene Sheltatree® was 76.6 cm in 1985 and 36.3 cm in 1986. The average tree trunk diameter was also found to be greater with Sheltatree® protectors during both years. With tree protectors, it may be possible to produce fruit trees and shade trees in the nursery more rapidly, reducing the number of years required before sale.

A field-ready solution to the resection problem given two coordinated points. An alternative field method of trigonometrical resection was derived. Resection is a topographic survey term referring to the field procedures and attendant calculations required to determine the coordinates of an instrument set-up position from two or more previously coordinated reference points. It is a required operation when previously coordinated points, obtained from a survey whose set-up position and reference orientation were not preserved, must be relocated. The method presented differs from previous resection solutions in that it can be readily calculated in the field and requires only two known reference points and one instrument set-up to provide the solution and associated field data checks. The procedure has particular application to engineering aspects of agricultural land development where topographic field surveys are often not referenced to provincial grid monument systems.

Subsoiler instrumentation system. An instrumentation system was developed and installed on a trailed tool bar subsoiler to record operating parameters during deep subsoiling. The system operates independently of the tractor and is controlled by a hand-held unit. Data are recorded by an ultraviolet chart recorder for field verification and digitally on magnetic tape for analysis.

Six parameters are recorded by the system. On one tine an octagonal ring transducer measures the horizontal force, vertical force, and the moment in the plane of those forces. Total draft is measured using a load cell located in a telescoped draw bar, and depth is measured by a linear displacement transducer attached to one of the support wheels. Wheel speed is measured with gears and proximity switches mounted on the wheel hubs.

The system is controlled by a 8088-based standard microprocessor. In addition to the processing unit (CPU), read-only memory (ROM), and random access memory (RAM), the system includes a real-time clock, serial and parallel input–ouput, and an analog-to-digital converter. Power is supplied by rechargeable gell cell units, and to save power the microprocessor remotely disables the tape drive and the ultraviolet chart recorder during standby.

The system has three modes of operation: display, chart–display, and chart–record. The display selection displays any of the input channels or the battery voltages on the liquid crystal display (LCD) portion of the hand-held unit for 30 s. Chart–display allows for display and turns on the ultraviolet chart recorder. The chart–record turns on the ultraviolet recorder, and data aquisition is performed at 100 Hz. Once complete, the system dumps the data to the tape upon command from the hand-held unit.

The system was field tested and the method of measuring wheel speed proved to be unsuitable because of shock and vibration. All other aspects of the system function adequately.

Soil and nutrient loss under various cropping practices. The effects of cropping practices on soil and nutrient loss were studied using runoff-erosion plots established at 8 and 11% slopes near Grand Falls, N.B. The results indicate that the average annual soil loss on the 11% slope during the period 1983–1985 was 0.05, 16.4, and 24.3 t/ha per year under grain, fallow, and potatoes, respectively. The soil loss of 24.3 t/ha per year under potatoes was reduced to 1.2 t/ha per year if potatoes were planted along the contour. Soil loss at 8% slope was similar to that at 11% slope but considerably less in magnitude.

Chemical analysis of sediment and runoff samples showed that average amount of nutrients lost from the plot of potatoes planted up and down the 11% slope was 74, 11, and 10 kg/ha for N, P_2O_5, and K_2O, respectively. The cost of these nutrients in terms of fertilizer is approximately $86. Considerable reduction in nutrient loss was found on the plot where potatoes were planted along the contour ($86 versus $7). Nutrient loss under grain was negligible. The study, therefore, helped to illustrate the benefit to farmers of modified cropping practices that help to reduce soil degradation.

The influence of subsoil acidity on alfalfa growth in the greenhouse. There is currently considerable interest in expansion of the alfalfa crop area in New Brunswick. New Brunswick soils are not particularly well suited to alfalfa production; over 50% of the arable soils are poorly drained and have compact and highly acidic subsoils. The objective of this experiment was to ascertain the extent by which alfalfa yields were reduced by high subsoil acidity after mechanical impediments to root growth had been removed.

When the pH (water) of the subsoil was increased to 7.0 by the addition of $CaCO_3$, alfalfa yields at the four harvests were 25, 12, 14, and 11% higher than from plots containing unamended subsoil (pH 5.2). Interestingly, when subsoil pH was increased to 7.0 by the addition of $MgCO_3$, alfalfa yields were increased (18.5%) only at the first harvest. Application of gypsum ($CaSO_4$) to the subsoil (Ca at 200 mg/g of soil) had no effect on soil pH or on alfalfa yield. Calcium uptake by alfalfa was increased by the addition of $CaCO_3$ (25%) over that attained on the unamended subsoil but was not affected by application of $CaSO_4$.

Alfalfa yields were always higher from subsoil that received $CaCO_3$ rather than $MgCO_3$, suggesting that the subsoil was deficient in Ca for alfalfa growth. However, when Ca was applied to the subsoil in the form of $CaSO_4$, which had no effect on soil pH, neither alfalfa yields nor Ca uptake were different from those attained on the unamended subsoil. It would appear that in this experiment, both the adverse effects of subsoil acidity and the low level of available Ca in the subsoil detrimentally affected alfalfa growth.

FERME EXPÉRIMENTALE SÉNATEUR HERVÉ J. MICHAUD, BOUCTOUCHE (N.-B.)

Brocoli. Depuis 1983, les cultivars mi-saison Emperor et Green Valiant dominent dans les essais de cultivars de transformation. Leur rendement respectif atteint 8,1 et 7,7 t/ha. De plus, l'apparence de leurs têtes centrales est acceptable pour le marché frais. Par ailleurs, parmi les cultivars hâtifs, le cultivar Septal a un rendement supérieur et les qualités requises pour le marché frais.

Panais. Une première évaluation de cultivars de panais en sol organique a démontré la supériorité de trois nouveaux cultivars, Lisbonnais, White Gem et Cobham Imp. Marrow, sur les cultivars Harris Model et Hollow Crown Improved qui sont présentement recommandés dans les provinces maritimes. Leurs rendements ont été de 44 %, 28 % et 20 % supérieurs respectivement. De plus, ils requièrent une saison de croissance légèrement plus courte.

Petits fruits. Des huit cultivars de sureaux établis en 1984 et 1985, un seul, Maxima, n'a pu mûrir ses fruits au cours de la saison 1986. Des rendements moyens de 8,6 et 4,7 t/ha ont été obtenus dans les plantations de 1984 et 1985 respectivement. Parmi les cultivars de gadelles, Consort (fruit noir), White Imperial (fruit blanc) et Red Lake (fruit rouge) sont les trois cultivars qui affichent les rendements les plus élevés. Chez les groseilles, Pixwell et Hinnonmake semblent prometteurs.

Soja. Dans la production du soja de cycle court pour le sud-est du Nouveau-Brunswick, le facteur le plus important demeure le choix du cultivar en fonction de sa saison de maturation. Les meilleurs rendements ont été obtenus par des semis hâtifs (avant le 6 juin) et par un écartement des rangs inférieur ou égal à 28 cm.

Ray-grass annuel. Dans les conditions du sud-est du Nouveau-Brunswick, la récolte du ray-grass annuel peut s'échelonner de la mi-juillet à la mi-octobre. Le cultivar Marshall s'est avéré le plus productif parmi les cultivars de type Westerwolds adaptés au foin mi-fane. Parmi les cultivars de type Italien adaptés au pâturage, Bartolini a produit autant que le cultivar témoin Lemtal.

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Quebec Region
Région du Québec

J.-J. Jasmin

F. Darisse

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Acting Program Specialist *Spécialiste en programmes, intérimaire*	F. Darisse, B.A., B.Sc. (Agr.)
Chief, Administration Section *Chef de la Section de l'administration*	R. Boulanger, L.Sces.Adm., Adm.A.

PRÉFACE

La Région du Québec, dont l'administration centrale est à Montréal, comprend quatre stations de recherches, trois fermes expérimentales et cinq stations satellites. En 1986, la région a administré un budget de 28,5 millions de dollars et employé 405 années-personnes dont 119 professionnels.

Les activités liées a la conservation et a l'amélioration des sols visent à etablir des taux optimums de fertilisation pour différentes cultures, à diminuer leur détérioration par de meilleures techniques culturales, le contrôle de l'érosion et la disposition des fumiers pour protéger l'environnement. Des recherches sont en cours pour obtenir des souches de *Rhizobium* plus résistantes aux basses températures et d'endomycorhizes spécifiques à plusieurs cultures. Le potentiel de production de plantes fourragères et oléagineuses, de céreales et de plantes de substitution au tabac est étudié en regard de types de sols variés.

Le programme de recherches sur le bétail a pour objet d'améliorer les systèmes d'alimentation et de conduite d'élevage en utilisant des aliments produits localement pour les bovins de boucherie, les bovins laitiers et les ovins. Des manipulations hormonales sont effectuées chez les bovins laitiers pour augmenter la production laitiere par vache, l'efficacité alimentaire et l'utilisation des fourrages. L'amelioration genetique fait appel à l'endocrinologie sous-jacente aux transferts d'embryons.

Les travaux de recherches sur le porc comprennent des manipulations hormonales pour accelérer la croissance et le developpement des animaux tout en augmentant la qualite de la viande par une diminution de la couche adipeuse. D'autres activites visent a augmenter le nombre de porcelets nes vivants par portée.

Le programme de recherches sur les céréales a pour objet de developper et d'identifier les cultivars supérieurs capables de satisfaire les besoins de l'est du Canada pour le rendement, la resistance aux maladies virales et exogenes, la tolérance au froid et l'adaptabilité climatique. L'amélioration génétique du maïs grain, du blé de printemps, du blé panifiable, du triticale, de l'orge de printemps et de l'avoine est une activité en cours. Des études de fertilisation et de regie s'ajoutent aux efforts de recherche.

La recherche sur les plantes fourragères vise à mettre au point des techniques supérieures de gestion des cultures, a sélectionner et a évaluer de nouveaux cultivars plus performants et plus résistants aux maladies, particulièrement la luzerne, à mettre au point une technologie ameliorée de récolte et de conservation des herbages, à évaluer la persistance et a determiner les mécanismes physiologiques de la resistance au froid des légumineuses. Le programme est étroitement lie aux recherches sur la fertilité, les symbioses végétales et la phytopathologie.

Les objectifs de recherches en cultures horticoles portent sur diverses especes de légumes, la pomme de terre, la gourgane, les fruits de vergers, les petits fruits, les plantes arômatiques condimentaires et medicinales et les plantes ornementales. L'amélioration génétique des crucifères, l'evaluation de diverses ressources phytogénétiques, la mise au point de techniques de gestion des sols et des cultures, la lutte chimique et biologique contre les principaux ravageurs des cultures légumières sont des travaux en cours. Quant aux fruits de verger, les travaux portent sur la gestion et la fertilisation des pommiers, ainsi que leur protection contre les ravageurs.

Les recherches axées sur les techniques de transformation et de commercialisation des aliments font appel à la biotechnologie et au génie alimentaire pour developper de nouvelles technologies et procédés de transformation et de conservation prolongée de produits laitiers, carnés et végétaux. Des efforts sont déployés pour développer des avenues nouvelles dans des domaines (arômes, colorants, enzymes, proteines, edulcorants) où il existe un potentiel commercial domestique et international.

Au cours de l'année 1986, R. Rioux a terminé une affectation par intérim d'un an à titre de spécialiste des programmes et F. Darisse a pris la releve a ce poste.

Les ceremonies d'inauguration officielle des nouveaux édifices de bureaux/laboratoires a Lennoxville et a La Pocatiere ont eu lieu respectivement le 20 septembre et le 28 novembre 1986.

Pour de plus amples renseignements au sujet des programmes specifiques au Quebec, on peut s'adresser aux etablissements concernés dont l'adresse postale est citee dans l'introduction de leurs rapports respectifs.

Jean-Jacques Jasmin
Directeur general

PREFACE

The Quebec Region, which headquarters in Montreal, includes four research stations, three experimental farms and five substations. In 1986, the region administered a budget of $28.5 million and employed a staff of 405 persons, including 119 professionals.

Studies on soil conservation and improvement include establishing optimum fertilization rates for various crops, reducing soil deterioration through improved cultural practices, controlling erosion, and protecting the environment through proper disposal of manure. Research is under way to obtain strains of *Rhizobium* more resistant to low temperatures and endomycorrhizae specific to various crops. The production potential of forage crops, oilseeds, cereals, and crops to replace tobacco is being studied on a variety of soils.

The livestock research program is designed to improve feeding and management systems for beef cattle, dairy cattle, and sheep by using locally grown feeds. Manipulation of hormones is being carried out on dairy cattle to increase milk yield per cow, feed efficiency, and forage utilization. Breed improvements are made possible through research in endocrinology, the science on which embryo transfer is based.

Manipulation of hormones is used in swine research to accelerate animal growth and development and improve meat quality by reducing fat. Other activities consist in increasing the number of liveborn piglets per litter.

The cereals research program is designed to develop and identify superior cultivars that will meet the needs of eastern Canada in terms of yield, resistance to viral and exogenous diseases, cold tolerance, and climatic adaptability. Breeding of grain corn, spring wheat, bread wheat, triticale, spring barley, and oats is under way. Fertilization and management studies complement the research efforts.

Forage research consists in developing better crop management techniques, selecting and evaluating cultivars (especially of alfalfa) with superior performance and resistance to disease, developing improved methods of harvesting and storing grasses, evaluating legume persistence, and determining the physiological mechanisms of cold resistance in legumes. The program is closely related to research on fertility, plant symbioses, and plant pathology.

The horticultural research program focuses on various types of vegetables, potatoes, broad beans, orchard fruits, small fruits, aromatic plants for use in condiments and medicines, and ornamentals. Research on the breeding of cole crops, the evaluation of various plant gene resources, the development of soil and crop management techniques, and the chemical and biological control of legume pests is under way. Orchard fruit research involves management and fertilization of apple trees and pest control.

Food processing and marketing research uses biotechnology and food engineering to develop new technology for processing dairy, meat, and plant products and extending storage life. Efforts are being made to develop various flavors, colors, enzymes, proteins, or sweeteners that offer commercial potential in Canada or abroad.

In 1986, R. Rioux completed a one-year assignment as acting program specialist and has been replaced by F. Darisse.

The official inauguration of the new office and laboratory buildings at Lennoxville and La Pocatière took place on 20 September and 28 November, 1986, respectively.

For further information on specific programs in Quebec, contact the establishment concerned. A mailing address appears in the introduction to each establishment's report.

Jean-Jacques Jasmin
Director General

Centre de recherches alimentaires Saint-Hyacinthe, Québec

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INTRODUCTION

Le Centre de recherches alimentaires de Saint-Hyacinthe est encore en 1986 en état de parachèvement et d'organisation. Comme son nom l'indique, c'est un établissement axé sur le secteur secondaire de l'alimentation. Ses installations correspondent aux grandes industries de la région où il se trouve, c'est-à-dire les industries du lait, des viandes, des fruits et légumes et de la boulangerie. De plus, le Centre a prévu des moyens pour contribuer au développement d'industries nouvelles dans des domaines où il existe un potentiel commercial national ou international. C'est le cas des biotechnologies appliquées à l'alimentaire, des arômes, des colorants, des enzymes, des protéines, des ingrédients divers comme les polysaccharides, les édulcorants, les fibres et bien d'autres. Des installations sont aussi prévues pour le développement et la mise au point de prototypes à l'échelle pilote d'équipements et de procédés alimentaires.

Le Centre est doté d'un irradiateur au cobalt pour la recherche et le développement de cette technologie dans le traitement et la conservation des aliments. Cet irradiateur a une puissance de 100 000 curies. Sa température peut être abaissée jusqu'à 0 °C et il sera possible de prévoir des unités pour opérer à des températures de congelation. La rotation des produits, la distance et la puissance de la source sont tous des paramètres contrôlables avec grande précision.

Une des caractéristiques principales du Centre est son ouverture à l'industrie. L'accent est mis sur le développement et le transfert de technologies applicables à l'industrie.

À cet égard, le concept d'intégration et le concept de partenariat y sont appliqués. Tous les intervenants concernés sont appelés à définir ensemble les axes et les priorités de recherche du Centre. L'association avec le client pour la réalisation des objectifs du Centre dépassera le stade de la consultation pour devenir un exercice de partenaires du développement. C'est dans cette ligne de pensée que l'industrie peut se prévaloir de l'accessibilité aux installations du Centre pour y effectuer sa propre recherche – développement concurrentielle ou non.

En 1986, le personnel du Centre a atteint 60 employés dont 18 chercheurs. Sept d'entre eux sont en formation. La plupart des autres ont donné de leur temps précieux pour l'organisation et la mise en route du Centre. Le présent rapport de recherche reflète nécessairement cette période d'organisation. Il n'en reste pas moins que nos chercheurs ont produit 23 publications scientifiques, 7 publications diverses et ont présenté 9 communications.

On peut obtenir des renseignements additionnels sur les activités du Centre en s'adressant au Centre de recherches alimentaires, 3600, boul. Casavant ouest, Saint-Hyacinthe, Québec, J2S 8E3; Tél.(514)773-1105.

René R. Riel
Directeur

BIOTECHNOLOGIE

Fromages. Des travaux menés en collaboration avec l'industrie et l'université ont conduit au développement d'un nouveau procédé permettant d'éliminer l'apparition du gaz tardif dans les fromages cheddar. Le procédé fait appel à l'utilisation de lactobacilles homofermentaires pour remplacer les agents causatifs qui ont été identifiés comme étant les lactobacilles hétérofermentaires. Cette recherche nous a permis de découvrir que la durée de maturation du fromage peut être réduite de 60 %.

Génie génétique. En génie génétique, nous avons collaboré avec le Conseil national de recherches; nous avons effectué avec succès le clonage de la lactase du *Streptococcus thermophilus* en *E. coli*. Nous allons tenter de transférer cette lactase clonée dans des hôtes qui peuvent intéresser l'industrie alimentaire.

FRUITS ET LÉGUMES

Asperges blanches. Des études de conservation des asperges blanches, en collaboration avec l'Université Laval, ont démontré que la vie de celles-ci est de 2 à 3 fois plus courte que celle des asperges vertes. Néanmoins, il a été observé que dans un environnement froid (de 2 à 3 °C) et humide (de 90 à 98 % H.R.) la durée de vie peut atteindre de 13 à 23 jours, ce qui est une grande amélioration sur les 4 à 5 jours de vie aux températures de 15 à 17 °C. Les travaux sur les asperges se poursuivent en tenant compte de tous les paramètres depuis le refroidissement à la récolte jusqu'aux emballages sous atmosphère modifiée.

Fraises. Il est bien entendu que la variété joue un rôle primordial dans la conservation des fraises, à moins d'abaisser les taux respiratoires par la conservation jusqu'à 2 ou 3 °C. Les variétés de fraises communément utilisées dans la région du Québec ont été catégorisées d'après leur taux respiratoire à la température ambiante. En choisissant les variétés les plus aptes à la conservation et en contrôlant l'atmosphère par le choix de l'emballage et des conditions de température et d'humidité, il a été facile d'obtenir des temps de conservation excédant deux semaines.

Taux respiratoires. La nouvelle méthodologie que nous proposons pour le calcul de taux respiratoires tirés de courbes obtenues expérimentalement à partir de l'analyse de la composition gazeuse en O_2, CO_2 et N_2 de respiromètres contenant des produits végétaux est basée sur l'utilisation de la technique des «splines». Un algorithme d'optimisation est employé pour sélectionner simultanément le degré de lissage optimum des trois courbes expérimentales. Cette méthode assure que les taux respiratoires évalués à partir des courbes lissées sont les estimations les plus précises et les plus cohérentes puisque l'optimisation est basée sur un critère de convergence unique.

PROTÉINES

Compte tenu de la variété de conditions auxquelles sont soumises les protéines au cours de la transformation des produits alimentaires, il s'avère important d'être capable de mesurer en laboratoire l'effet des traitements sur la valeur biologique des protéines.

À cet égard, nous avons collaboré avec l'Université Laval à la mise au point d'un dialyseur approprié qui permet de mesurer directement le degré de digestibilité des protéines. En principe, celles-ci sont soumises, dans un premier temps, à une protéolyse peptique dans un système clos, puis ensuite l'hydrolyse est poursuivie avec des enzymes pancréatiques dans une cellule à digestion avec élimination continuelle des produits digérés par dialyse. De cette façon, la réaction d'hydrolyse n'est pas inhibée par l'accumulation des produits de la digestion. De plus, l'analyse de ces derniers en fonction du temps apporte beaucoup d'éclairage sur les cinétiques de la digestion protéique.

Ainsi donc, cette technique in vitro à deux étapes s'avère très avantageuse pour simuler la digestion in vivo dans les conditions optimales de pH et de température sans les inconvénients de coût, de main-d'oeuvre, de temps et d'imprécision des méthodes in vivo.

La caractérisation et la sélection des bactéries sur la base de leur activité protéolytique répond à un besoin grandissant en industrie alimentaire. Les aspects fonctionnels, nutritionnels et sensoriels sont très souvent améliorés par l'hydrolyse partielle et contrôlée des protéines dans les aliments. A cette fin, nous avons mis au point avec des collaborateurs de l'Université Laval une méthode de diffusion simple et rapide pour sélectionner des microorganismes d'après leur aptitude à digérer les protéines d'origine animale ou d'origine végétale.

LES VIANDES

Les travaux sur la qualité des viandes et des produits carnés ont été poursuivis au Laboratoire de biochimie musculaire du Ministère au Collège Macdonald. Le travail de méthodologie s'est poursuivi. Une méthode a été développée pour la séparation complète de tous les 25 acides aminés standards et pour leur mesure quantitative à des niveaux picomolaires. De plus, cette même méthode permet des résolutions difficiles comme la 4-hydroxyproline, la dioxyde de méthionine, les sucres aminés, etc.

Une autre méthode mise au point et qui est relativement rapide et sensible permet de déterminer le tryptophane, la desmosine, l'isodesmosine, la 5-hydroxylysine et la lysinoalanine. Ce dernier composé a un intérêt particulier à cause de sa grande toxicité alimentaire qu'il devient important de déceler en rapport avec certains traitements inopportuns que peuvent subir les produits protéagineux. À partir de la détermination de la 4-hydroxyproline, il nous est possible d'établir la teneur en tissus conjonctifs des muscles et des produits carnés.

Ceci porte à cinq les méthodes analytiques qui ont été développées au Laboratoire de biochimie musculaire pour la détermination de plus de 50 acides aminés dans les protéines et les tissus avec une sensibilité et une résolution qui dépassent toute autre méthode à ce jour. Les méthodes développées contournent les difficultés d'interférence des dipeptides, histidine, d'extraction sélective des protéines intracellulaires et d'isolation des principales protéines du muscle.

Des équations mathématiques simplifiées ont été mises au point pour usage de routine au niveau de l'industrie, permettant de calculer, à partir d'acides aminés uniques, les teneurs en myosine, en actine, en collagène et en élastine dans les produits carnés.

Une étude élaborée a été complétée relativement aux variations des teneurs en Nτ-méthylhistidine, 5-hydroxylysine et desmosine d'une variété de muscles chez trois espèces bouchères. Étant donné l'invariabilité de ces teneurs, il est possible d'évaluer avec précision les quantités de protéines de tissus conjonctifs et myofibrillaires dans les mélanges carnés.

L'approche analytique proposée pour caractériser les mélanges carnés repose sur la détermination directe de leurs teneurs en collagènes et en muscle squelettique à partir des quantités de 5-hydroxylysine et de Nτ-méthylhistidine présents à partir des quantités de desmosine présentes. En soustrayant des protéines totales d'un échantillon de mélange carné, les protéines des muscles intracellulaires et la matrice extracellulaire, on obtient une évaluation précise des protéines étrangères présentes. Cette étude extensive relative à des méthodologies protéiques a conduit au développement d'une méthode rapide pour déterminer les teneurs absolues en protéines dans les viandes et les produits carnés.

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Station de recherches, Lennoxville Québec

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Administration

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J. de Léséleuc	Services administratifs

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J.J. Matte, B.Sc.(Agr.), M.Sc., Ph.D.	Nutrition – porcs
S.A. Pommier, B.Sc., M.Sc., Ph.D.	Qualité des viandes – bovins, porcs, moutons

Production laitière

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H. Lapierre,[5] B.A., M.Sc.	Physiologie et nutrition
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N.R. St-Pierre, B.Sc.(Agr.), M.Sc., Ph.D.	Analyse de systèmes
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Production fourragère et sols

J.-L. Dionne, B.A., B.Sc.(Agr.), Ph.D.	Chef de section; fertilité des sols
G.M. Barnett, B.Sc.(Agr.), M.Sc.	Régie et environnement
C. Fernet, B.Sc.	Amélioration des plantes
W.N. Mason, B.Sc.(Agr.), M.Sc., Ph.D.	Régie et qualité des plantes fourragères
A.R. Pesant, B.Sc.(Agr.), M.Sc.	Physique des sols
R. Simard,[7] B.Sc.(Agr.), M.Sc.	Fertilité des sols

Départ

J. Bernier, B.Sc.(Agr.), M.Sc., Ph.D. Département de zootechnie, Université Laval, décembre 1986	Régie – boeufs

CHERCHEURS INVITÉS

S. Robert, D.M.V., Ph.D. Post-doctorat, CRM	Ethologie et physiologie

Étudiants à la maitrise

P. Bilodeau responsable, D. Petitclerc	Physiologie de la lactation
R. Bilodeau responsable, J.J. Matte	Nutrition – porcs
G. Guertin responsables, B. Lachance et D. Petitclerc	Nutrition – jeunes ruminants
P. Lacasse responsables, D. Petitclerc et G. Pelletier	Physiologie de la lactation
M.A. Lalime responsable, A.R. Pesant	Physique des sols
D.M. Marchand responsable, G.L. Roy	Génétique – bovins laitiers
C. Moore responsable, M.H. Fahmy	Physiologie de la reproduction
H. Ringuet responsables, D. Petitclerc et G. Pelletier	Physiologie de la lactation
S. Sarhad responsable, A.R. Pesant	Physique des sols
P. Villeneuve responsable, L.A. Guilbault	Physiologie de la reproduction

Étudiants au doctorat

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INTRODUCTION

En 1986, la Station de recherches de Lennoxville a emménagé dans un nouvel édifice de bureaux et laboratoires, mettant ainsi à la disposition de ses chercheurs des installations modernes et des équipements scientifiques adaptés à une recherche d'avant-garde. Grâce à une consultation et une concertation intensifiées avec les universités, l'industrie et la province, les programmes se sont cristallisés pour répondre encore mieux aux besoins du milieu et également pour ouvrir la voie vers de nouvelles technologies.

La recherche de la station porte sur cinq programmes principaux: les bovins laitiers, les bovins de boucherie, les porcs, les plantes fourragères et les sols. Des équipes multidisciplinaires, comportant des spécialistes en génétique, nutrition, physiologie, comportement et régie, travaillent à augmenter l'efficacité des principales productions animales du Québec. Parmi les domaines de pointe dans lesquels oeuvrent les chercheurs de la station, on retrouve les manipulations hormonales et le transfert d'embryon, deux domaines qui auront un impact certain sur l'industrie animale. La recherche en plantes fourragères vise à augmenter l'utilisation par le ruminant de cette denrée si abondante au Québec. Des travaux sur la régie des fumiers, la fertilité et l'érosion ont pour objectifs d'augmenter la productivité des sols et d'en empêcher la dégradation.

On peut obtenir des renseignements plus complets en écrivant directement aux chercheurs à l'adresse suivante: Station de recherches, Direction générale de la recherche, Agriculture Canada, C.P. 90, 2000 route 108 est, Lennoxville, Québec, J1M 1Z3; Tél. (819) 565-9171.

J.C. St-Pierre
Directeur

PRODUCTION ANIMALE

Bovins laitiers

Croissance et production laitière de génisses de différents poids à la naissance. Des génisses du Projet national d'amélioration génétique de la vache laitière ont été réparties en quatre groupes de poids à la naissance d'après le poids moyen à la naissance de chacun des quatre génotypes représentés et aussi d'après la parité de la mère. Les poids des deux groupes intermédiaires avaient un écart de plus ou moins 3 kg de la moyenne de chacun des sous-groupes tandis que les génisses du groupe le plus léger pesaient au moins 3 kg de moins que la moyenne et les génisses du groupe le plus lourd pesaient 3 kg de plus que la moyenne. Les poids à 26 et 50 semaines d'âge et au vêlage étaient significativement différents ($P < 0,05$) pour les quatre groupes de poids à la naissance. Les croissances durant les différents intervalles avaient un écart aussi grand. Les génisses les plus légères à la naissance étaient les plus légères à un premier vêlage à l'âge de 22,4 mois; elles étaient moins hautes au garrot et elles avaient un plus petit tour de poitrine. Le contraire était vrai pour les génisses du groupe le plus lourd. Les génisses des groupes moyens étaient intermédiaires en poids, en croissance et en taille. Le rendement en lait, en protéines et en gras de la première lactation était semblable pour les génisses des quatre groupes de poids à la naissance. La survie jusqu'à 6 mois d'âge des génisses du groupe léger était plus basse. Par la suite, cependant, le pourcentage de survie des génisses de tous les groupes était le même.

L'effet de la dose de somatocrinine humaine ($hGRF(1\text{-}44)NH_2$) *et de son fragment* ($(1\text{-}29)NH_2$) *sur la libération de l'hormone de croissance (GH) chez la génisse et le porcelet.* Une étude a été entreprise dans le but d'évaluer l'activité biologique de deux peptides synthétiques: le $\text{hGRF}(1\text{-}44)\text{NH}_2$ possédant la séquence naturelle de la somatocrinine humaine et l'un de ses fragments, le $\text{hGRF}(1\text{-}29)\text{NH}_2$. Chez la génisse ($n = 10$) et le porcelet ($n = 10$), la réponse en GH suite à l'injection intraveineuse de différentes doses (0,0, 0,067, 0,2, 0,6 et 1,8 nmol.kg^{1} de poids vif) de chaque peptide a été évaluée en utilisant un double carré latin 5 × 5. Cinq animaux ont été injectés avec soit le $\text{hGRF}(1\text{-}44)\text{NH}_2$ ou le $\text{hGRF}(1\text{-}29)\text{NH}_2$; les effets principaux étaient la dose ($n = 5$) de peptides injectés et le nombre de jours ($n = 5$) d'injections. Chez les deux espèces, les deux peptides ont stimulé de façon équivalente la sécrétion de GH. Les concentrations moyennes maximales (73,9 contre 73,0 ng.mL^{-1}; 56,1 contre 45,2 ng.mL^{-1}) et les aires sous la courbe de réponse en GH (4 509 contre 3 891 ng.mL^{-1}.min; 2 516 contre 1 696 ng.mL^{-1}.min) n'ont pas été différentes ($P > 0,05$) entre les deux molécules chez les génisses et les porcelets, respectivement. Cependant, la réponse en GH suite à l'injection des peptides a varié beaucoup plus chez les porcelets comparativement aux génisses. La forme naturelle de la somatocrinine humaine et son fragment (1-29)NH_2 ont donc une activité biologique équivalente sur la libération de GH chez la génisse et le porcelet.

Bovins de boucherie

Influence de l'infusion de prostaglandine F2$_{\alpha}$ et du sevrage sur les morphologies ovarienne et utérine en début de période postpartum chez la vache de boucherie. Du 2^{e} au 13^{e} jour après le vêlage, des vaches de boucherie ($N = 24$) ont reçu une infusion continue de prostaglandine F2$_{\alpha}$ (PGF2$_{\alpha}$; 25 mg.jour^{-1}) ou d'une solution saline physiologique. Les animaux ont été abattus au jour 15 ou au jour 35 après le vêlage et la morphologie ovarienne et utérine a été analysée. Le poids et le diamètre du cervix, de même que le poids, la longueur et le diamètre moyen des deux cornes utérines étaient plus élevés chez les animaux abattus au jour 15 qu'au jour 35 après le vêlage. Cependant, quel que soit le jour d'abattage, ces paramètres cervicaux et utérins étaient similaires entre les vaches infusées avec la PGF2$_{\alpha}$ et celles infusées avec la solution saline. Le nombre de follicules de diamètre moyen (3-5 mm) et de grand diamètre (>5 mm) était plus faible chez les vaches abattues au jour 15 que chez celles abattues au jour 35. Le sevrage des veaux au jour 31 a provoqué une augmentation du nombre de follicules de diamètre moyen chez les vaches infusées à la saline alors que le nombre de follicules de cette même taille était réduit par le sevrage lorsque les vaches ont été infusées avec la PGF2$_{\alpha}$. Le nombre de gros follicules et le nombre d'ovulations avaient tendance à être plus élevés chez les vaches infusées avec la PGF2$_{\alpha}$. Le diamètre moyen du plus gros follicule sur l'ovaire ipsilatéral au corps jaune de la gestation précédente était plus élevé au jour 15 et au jour 35 chez les vaches infusées avec la PGF2$_{\alpha}$. Sur l'ovaire contralatéral, une telle différence n'a été observée qu'au jour 15. Ces résultats indiquent qu'une infusion de PGF2$_{\alpha}$ tôt en période postpartum n'influence pas l'involution utérine mais stimule le développement des gros follicules principalement sur l'ovaire ipsilatéral.

Effets des systèmes alimentaires sur les performances et la qualité des carcasses des taurillons de race Holstein. Dix-huit traitements alimentaires ont été comparés avec 184 taurillons de race Holstein. L'expérience s'est déroulée en trois phases. Au cours de la phase I, un groupe de taurillons au pâturage ont reçu 1 kg de concentré par jour; les deux autres groupes en réclusion ont été alimentés à l'ensilage d'herbe additionné de deux niveaux de concentré (1 kg ou à volonté). Au cours de la phase II, les taurillons ont été réassignés à des traitements à l'ensilage de maïs avec un supplément de 0, 250 et 500 g de tourteau de soja par tête et par jour (jusqu'au poids vif de 400 kg). Au cours de la phase III, les animaux ont été répartis uniformément selon le poids et les régimes antérieurs. Les taurillons de chacun des groupes ont reçu une ration à base d'ensilage de maïs additionnée d'orge (5 kg ou à volonté). Tous les animaux ont été abattus au poids vif de 525 kg.

Les taurillons au pâturage recevant 1 kg de concentré par jour ont obtenu un gain de poids supérieur à celui des taurillons gardés en réclusion recevant 1 kg de concentré par jour. L'addition de 500 g de tourteau de soja à la ration a permis d'améliorer de 50 % le gain de poids quotidien et de 28 % l'efficacité alimentaire. En phase III, l'orge servie à volonté a amélioré de 17 % l'efficacité alimentaire. Les taurillons, gardés au pâturage et recevant 1 kg de concentré par jour au début de l'expérience, puis ensuite nourris à l'ensilage de maïs additionné de 500 g de tourteau de soja en phase II, ont obtenu un gain de poids moyen quotidien variant entre 920 et 960 g. Cette performance est comparable à celle des taurillons alimentés à l'ensilage d'herbe et recevant des concentrés à volonté au cours de la phase I.

Les variables associées au tissu adipeux (épaisseur de gras à la 12^{e} côte, couverture de gras, persillage, pourcentage de gras à la 12^{e} côte et classification des carcasses) ont été influencées par les différents traitements alimentaires. Les coefficients de corrélation ont démontré des relations significatives entre les différents paramètres: catégorie de carcasse et épaisseur de gras à la 12^{e} côte ($R = -0,79$), catégorie de la carcasse et couverture de gras ($R = 0,69$), épaisseur de gras et pourcentage de gras à la 12^{e} côte ($R = 0,54$), pourcentage de gras et pourcentage de muscle à la 12^e côte ($R = -0,77$). La corrélation entre l'appréciation de la catégorie de la carcasse par les mesures d'épaisseur de gras in vivo au moyen des ultrasons et la classification de la carcasse à l'abattoir était de 0,56.

Porcs

Influence du sevrage sur les concentrations de lactose plasmatique chez la truie. Vingt truies ont été utilisées pour étudier la relation entre l'évolution du lactose plasmatique après sevrage et diverses performances zootechniques, telles l'intervalle sevrage – saillie, la production laitière, la perte de poids des truies et le gain de poids des porcelets pendant la lactation. Les concentrations moyennes de lactose plasmatique et leurs erreurs standard correspondantes ont été de 51,9 ± 4,0, 35,2 ± 3,5, 41,0 ± 4,7, 60,3 ± 13,1, 110,6 ± 20,3, 183,2 ± 23,2, 172,8 ± 19,4, 156,9 ± 16,2 et 91,3 ± 11,0 à respectivement 2, 10, 18, 26, 34, 42, 50, 58 et 66 heures après le sevrage. Aucune corrélation significative n'a été observée entre, d'un côté, les différentes caractéristiques du pic de lactose, telles la hauteur, la surface sous la courbe, l'étalement et le temps où le pic se produit et, de l'autre, l'intervalle sevrage – saillie, la production laitière, la perte de poids des truies et le gain de poids des porcelets pendant la lactation. Ces résultats indiquent que le pic de lactose plasmatique observé après le sevrage n'est pas impliqué dans le contrôle du retour en oestrus chez la truie.

Le lactosérum dans l'alimentation liquide des porcs en croissance. Une étude d'une durée de 3 ans a été réalisée dans le but de comparer les effets de l'utilisation du lactosérum liquide (6,5 % de matière sèche). Deux systèmes d'alimentation ont été comparés: une alimentation liquide sous forme de soupe et une alimentation conventionnelle composée d'aliments secs moulus. Les résultats provenant de 320 porcs répartis sur 13 lots démontrent, qu'entre 31 et 68 kg de poids, un apport de 29 % de lactosérum dans la ration, sur une base de matière sèche, n'influence pas le gain quotidien. L'efficacité alimentaire est améliorée de 4,2 % (2,77 contre 2,89) et la consommation quotidienne de matière sèche est diminuée de 4,7 % (1,81 contre 1,90 kg). En phase de finition, soit de 68 à 98 kg de poids, les porcs recevant du lactosérum ont un meilleur gain de poids quotidien de 8,1 % (0,67 contre 0,62 kg), ils ont consommé 5,3 % plus de matière sèche (2,40 contre 2,28 kg) et ils ont eu une meilleure efficacité alimentaire de 3,3 % (3,57 contre 3,69) que les porcs témoins. Pour toute la période d'engraissement, le gain de poids quotidien des porcs nourris au lactosérum a été supérieur de 3,6 % (0,66 contre 0,64 kg) et leur efficacité alimentaire a été meilleure (3,4 %; 3,13 contre 3,24) comparativement au groupe témoin. Le rendement des carcasses à l'abattage a été inférieur (78,7 contre 80,3 %) chez les porcs alimentés au lactosérum. Aucune différence significative ($P > 0,05$) n'a été enregistrée au niveau de l'épaisseur du gras dorsal et de l'indice de classification. Avec un système d'alimentation liquide, il est donc avantageux d'utiliser 30 % de lactosérum liquide, ce qui représente une consommation quotidienne de 7,3 L de lactosérum.

L'influence du sevrage précoce sur le comportement de la truie en cage de mise bas. Vingt-cinq truies primipares logées dans des cages de mise bas conventionnelles ont été observées aux jours 17, 27 et 28 de lactation dans le but d'évaluer l'influence du sevrage à 4 semaines sur le comportement et le bien-être des animaux. La fréquence de cinq postures et de neuf activités a été mesurée et comparée en fonction du jour et de la période d'observation. Les résultats ont montré une variation du profil comportemental en fonction du stade de lactation, distribuée de façon non uniforme entre le jour et la nuit. Les truies étaient plus nerveuses quand les porcelets atteignaient 27 jours d'âge que lorsqu'ils étaient âgés de 17 jours. Le pourcentage de temps consacré au repos avait diminué de 5 % et les animaux étaient plus fréquemment debout, sans activité. Les truies se reposaient plus souvent couchées sur le ventre et moins souvent sur le côté, indiquant une moins bonne relaxation musculaire et une plus faible fréquence de sommeil profond. Ce profil comportemental semblait être adopté dans le but de réduire l'accès des porcelets à la glande mammaire. Au moment du sevrage, les truies étaient plus agitées que les jours précédents. Cependant, les indices d'agitation observés lors du retrait des porcelets étaient transitoires et s'atténuaient au cours de la nuit suivante. Le temps total de repos pour ce 24 heures excédait même de 6 % celui du jour 27. Il demeure donc souhaitable de réaliser le sevrage à 4 semaines dans nos conditions modernes d'élevage intensif.

Moutons

Détermination par laparoscopie de la saison d'activité sexuelle et du taux d'ovulation de brebis DLS. Les ovaires de 19 brebis DLS (1/2 Dorset, 1/4 Leicester, 1/4 Suffolk) ont été observés par des laparoscopies répétées à des intervalles de 16 à 18 jours afin de déterminer la longueur de la saison d'activité sexuelle. Neuf brebis (47 %) avaient des corps jaunes (CJ) et/ou des corps albicans (CA) entre le 22 avril et le 26 mai 1983. La date moyenne du premier oestrus accompagné de monte était le 28 août ± 10 jours en 1983 et le 20 septembre ± 15 jours en 1984. Les intervalles entre l'observation du premier et du dernier corps jaune et entre la première et la dernière monte étaient respectivement de 251 ± 28 jours et 222 ± 32 jours. En 1984, les dates moyennes de la fin de la monte et de la dernière observation des CJ et des CA étaient, respectivement, le 11 avril ± 27 jours, le 26 avril ± 27 jours, et le 9 mai ± 30 jours. L'anoestrus a duré 133 ± 28 jours. Les taux moyens d'ovulation dans les deux derniers cycles de la saison et dans les deux premiers de la saison suivante étaient, respectivement, de 1,6 ± 0,53 et 1,7 ± 0,65 en 1983 et de 1,1 ± 0,31 et 1,4 ± 0,71 en 1984.

PRODUCTIONS VÉGÉTALES ET SOLS

Fumure azotée et potassique pour la production de céréales. Des expériences se sont poursuivies pendant une période de 3 ans dans le but de déterminer quelles étaient les doses d'azote qui produiraient de bons rendements de céréales tout en maintenant la verse à un degré acceptable et d'évaluer jusqu'à quel point l'utilisation du potassium pouvait diminuer l'effet de l'azote sur la verse. L'avoine Scott, l'orge Loyola et le blé Opal ont été semés dans le loam sableux Sheldon et l'argile Lennoxville. L'azote, sous forme de nitrate d'ammoniaque, a été appliqué à des doses de 0, 40, 80 et 160 kg.ha ^{1} et le potassium, sous forme de muriate de potassium, à raison de 0, 100 et 200 kg.ha ^{1}. L'orge a mieux répondu à la fumure azotée que l'avoine et le blé. Les augmentations moyennes de rendements ont été de 30 % pour l'orge, comparativement à 13 % pour l'avoine et 15 % pour le blé. Des augmentations de 30 % des rendements en paille ont été observées suite à la fumure azotée, comparativement à 16 % pour le grain. L'indice de récolte (% de grains) a diminué avec les doses d'azote. Les doses d'azote à recommander se situeraient entre 40 et 80 kg.ha ^{1} pour l'avoine et le blé et pourraient être augmentées jusqu'à 160 kg.ha ^{1} pour l'orge. Les céréales ont répondu aux applications de potassium lorsqu'elles étaient cultivées sur le loam sableux Sheldon et la dose recommandable serait de 100 kg.ha ^{1}. Le degré de verse des céréales a varié selon les années, les espèces et la dose d'azote appliquée au sol. L'avoine a été beaucoup plus atteinte par la verse mais le blé y a mieux résisté. Les indices de verse ont augmenté avec les doses d'azote. La fumure potassique a diminué le degré de verse du blé. Le degré de verse devient élevé si on applique l'azote à une dose supérieure à 40 kg.ha ^{1} sur les sols destinés à la culture de l'avoine. Cette dose serait de 80 kg.ha ^{1} pour l'orge et le blé.

Production de céréales de printemps sur différents sols. Les effets des dates, de la population de semis et du placement de la semence sur la production des céréales de printemps ont été étudiés. L'orge, le blé et l'avoine ont été cultivés sur quatre types de sols. Sur tous les types de sols, les semis hâtifs ont produit de meilleurs rendements que les semis tardifs. Le même effet a été produit par le placement de la semence en bandes, comparativement au semis à la volée. Par contre, la dose de semis produisant le meilleur rendement a varié selon le type de sol et l'espèce de céréale. Les meilleurs rendements produits par les semis hâtifs et le placement de la semence en bandes ont été reliés en grande partie à une population élevée d'épis et au poids élevé des épis à maturité. Cependant l'importance de ces deux facteurs a varié selon les types de sols. Sur le loam de l'Anse, les rendements élevés ont été associés à une population élevée d'épis tandis que le poids des épis a été le facteur important sur l'argile Kamouraska et le loam argileux du Creux. Sur le loam sablo-graveleux Saint-André, le faible rendement a été le résultat d'une maturité hâtive produisant de petits grains de faible densité. Les rendements élevés de l'avoine ont été reliés à une population élevée de panicules. Le poids élevé des épis a été le facteur le plus important dans les rendements de l'orge et le faible poids des épis a limité les rendements de blé.

Influence de la température et des régimes hydriques sur le comportement des céréales et des plantes fourragères. Une expérience a été réalisée en serre dans des pots remplis de silice afin d'étudier l'effet de la température (15 et 26 °C) et des régimes hydriques (90, 45 et 30 % de la capacité optimale de rétention d'eau) sur le rendement et la composition minérale de six plantes fourragères et de quatre céréales. En général, les céréales ont produit les plus hauts rendements suivies des graminées et des légumineuses. L'élévation de la température de 15 °C à 26 °C a permis d'augmenter de 26 % les rendements en matière sèche de la portion aérienne. Aucune différence significative n'a été enregistrée pour la portion racinaire des plantes. Le maïs, le lotier, le millet japonais, la luzerne, le trèfle et l'alpiste roseau ont été les espèces dont la croissance a été la plus favorisée par une température de 26 °C. Par contre, à une température de 15 °C, l'avoine, l'orge, le blé et la fléole des prés ont donné des rendements supérieurs. On a obtenu une interaction significative entre les températures de l'air et les régimes hydriques sur le contenu en B, Mn et P de la partie aérienne des plantes. Dans l'ensemble, l'absorption du B et du Mn par les dix espèces végétales a augmenté à une température de 26 °C tandis qu'elle diminuait légèrement pour N, P et K. Lorsqu'on a augmenté la réserve en eau de 30 à 90 % de la capacité de rétention optimale, les rendements de la partie aérienne et des racines ont pratiquement triplé. Le contenu en N, K, B et Mn a suivi la même tendance à l'exception du P qui a été diminué en régime hydrique impliquant des périodes de sécheresse prolongées. L'humidité n'a pas influencé le contenu en Cu et Fe des plantes. De plus, on a noté une plus grande concentration de Mn, Cu et Fe dans les racines, avec des quantités de quatre à cinq fois supérieures à celles de la partie aérienne.

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Départs

R. Bergeron, B.Sc.(Agr.), M.Sc. Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, Québec, décembre 1986	Génétique des bovins laitiers
C. DeKimpe, B.A., Ing.Chim. et Ing.Agr., D.Sc.Agr. Muté au Centre de recherches sur les terres, Agriculture Canada, Ottawa, juin 1986	Genèse des sols
J.-M. Deschênes, B.Sc.(Agr.), M.Sc., Ph.D. Muté au Centre de recherches en phytotechnie, Agriculture Canada, Ottawa, mai 1986.	Écologie
Y. Dion, B.Sc.(Agr.), M.Sc. Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, St-Hyacinthe, mai 1986	Génétique des céréales
H.J. Hope, B.Sc., M.Sc., Ph.D. Muté au Centre de recherches en phytotechnie, Agriculture Canada, Ottawa, juin 1986	Résistance au froid – mécanisme
R. Paquin,[10] B.A., B.Sc.(Agr.), M.Sc., Ph.D. Retraité, mai 1986	Survie à l'hiver des plantes

CHERCHEURS INVITÉS

D.D. Jain, Ph.D. Post-doctorat, Conseil national de la recherche du Canada	Biotechnologie
S. Caudry-Reznick, Ph.D. Post-doctorat, Conseil des recherches en sciences naturelles et génie du Canada	Génétique bactérienne

Étudiants à la maîtrise

S. Beauregard responsable, P. Savoie	Génie rural
F. Bélanger responsable, J.-P. Dubuc	Physiologie végétale

A. Bertrand responsable, R. Paquin	Physiologie végétale
F. Cheour responsable, A. Comeau	Pathologie des céréales
R. Côté responsable, L. Bordeleau	Biologie végétale
D. Coutlée responsable, R. Lalande	Rhizobactéries
S. Delaney responsable, P. Nadeau	Biochimie végétale
S. Despatie responsable, V. Furlan	Endomycorhizes
L. Diaz del Castillo responsable, L. Bordeleau	Biochimie bactérienne
J. Durand responsable, J. Surprenant	Amélioration et génétique des graminées fourragères
A. Marcoux responsable, P. Savoie	Génie rural
T. Paré responsable, R. Lalande	Symbiose végétale
K. Phambu responsable, V. Furlan	Endomycorhizes
S. Pouleur responsable, L. Couture	Pathologie des céréales
P. Renaud responsable, J. Surprenant	Science et technologie des aliments
N. Samson responsable, C. Lemieux	Malherbologie
R. Sauvageau responsable, L. Bordeleau	Biochimie bactérienne
A. Taya responsable, L. Couture	Pathologie des céréales
G. Thibault responsable, P. Savoie	Génie rural
C. Tremblay responsable, A. Comeau	Entomologie
D. Tremblay responsable, P. Savoie	Génie rural
F. Voisine responsable, P. Nadeau	Biochimie végétale

Étudiants au doctorat

F. Bigras responsable, R. Paquin	Physiologie végétale
P.-C. Bilwaneza responsable, L. Bordeleau	Biochimie bactérienne
J. Collin responsable, A. Comeau	Amélioration des céréales
S. Gagné responsable, C. Richard	Rhizobactéries
J. Grandmaison responsable, V. Furlan	Endomycorhizes
S. Laberge[11] responsable, L. Bordeleau	Génétique bactérienne

P. Lafontaine responsable, R. Lalande	Symbiose végétale
C. Nkongolo responsable, A. Comeau	Amélioration des céréales
A. Plourde responsable, A. Comeau	Amélioration des céréales
C. Pomar responsable, P. Savoie	Zootechnie
S. Rioux responsable, L. Couture	Pathologie des céréales
C. Thériault responsable, A. Comeau	Amélioration des céréales

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INTRODUCTION

En 1986, on a continué l'aménagement de la Ferme expérimentale Chapais à Saint-David pour mieux l'adapter au travail expérimental. La Ferme expérimentale de Normandin a célébré son cinquantième anniversaire de fondation et on a procédé à l'inauguration officielle du nouveau complexe administratif et scientifique à la Ferme de La Pocatière. On a également entrepris des expériences en champ à Évain près de Rouyn en Abitibi.

Les travaux de recherches sont orientés vers les productions fourragères, céréalières, ovines, bovines, horticoles dont la pomme de terre, ainsi que les sols. Pour de plus amples renseignements s'adresser à : Station de recherches, Agriculture Canada, 2560 boulevard Hochelaga, Sainte-Foy, Québec, G1V 2J3; Tél. (418) 648-4161.

S.J. Bourget
Directeur

LES PLANTES FOURRAGÈRES

Amélioration génétique des légumineuses

Développement d'un cultivar de luzerne. Dans le cadre du programme d'amélioration génétique de la luzerne pour une production supérieure et une meilleure persistance, une population expérimentale (SF-8001) a donné, sur une moyenne de 31 années/stations, 6 % plus de rendement que le cultivar Saranac. Cette lignée a reçu le support du Comité des plantes fourragères du Conseil des productions végétales du Québec (CPVQ) pour appuyer une demande d'enregistrement lorsque la semence du sélectionneur sera disponible.

Résistance à la verticilliose. Trois cycles de sélection pratiqués chez deux populations de luzerne ont permis d'accroître de 4 à 40 % le niveau de résistance de cette plante à la verticilliose, niveau qui est considéré comme acceptable pour limiter les effets de cette maladie sur le rendement et le peuplement de cette espèce.

Amélioration génétique des graminées

Regain de la fléole. L'étude des effets de l'irrigation et de la fertilisation azotée sur le regain de la fléole des prés a été poursuivie en 1986. Les résultats préliminaires montrent une augmentation de l'héritabilité du regain de la fléole en fonction de la fertilisation azotée lorsque cette culture, établie sur une argile ou un loam sablo-graveleux, est exploitée avec ou sans irrigation.

Qualité nutritive de la fléole. Les derniers résultats d'une étude entreprise en 1983 sur l'héritabilité du rendement en matière sèche et de certaines propriétés physico-chimiques reliées à la qualité nutritive de la fléole des prés indiquent que les valeurs varient entre 0,46 et 0,78 dépendant des caractères étudiés. Par ailleurs, après un premier cycle de sélection, l'héritabilité de la teneur en protéine, de la digestibilité et du rendement digestible était de 0,69, 0,67 et 0,27 respectivement.

Comportement du chiendent hybride. Suite au croisement de génotypes de chiendent hybride (*Agropyron repens* × *Agropyron spicatum*) sélectionnés pour un port dressé, des feuilles larges et une faible croissance radiale des rhizomes, deux composites équilibrés ont été semés au printemps 1986. La vitesse d'établissement du chiendent hybride a été moins rapide que celle des graminées normalement recommandées dans l'est du Canada.

Pathologie

Bactéries glaçogènes. Des bactéries glaçogènes isolées des racines de luzerne ont été identifiées; ce sont les *Pseudomonas facilis*, *P. fluorescens*, *P. maltophilia*, *P. putida* et *P. syringae* ainsi que l'*Erwinia herbicola*. De la microflore bactérienne totale de racines de luzerne, 11,3 % ou $5{,}3 \times 10^4$ CFU/g de xylène et $3{,}5 \times 10^4$ CFU/g de xylène étaient glaçogènes chez les cultivars Saranac et Iroquois respectivement. L'inoculation d'une de ces bactéries qui favorisent la formation de glace par nucléation hétérogène a abaissé le niveau de résistance au gel de la luzerne en congélateur programmé.

Malherbologie

Établissement d'un mélange fourrager. Les résultats obtenus au cours d'une étude visant à déterminer l'impact de l'orge et des populations de mauvaises herbes sur l'établissement de la fléole des prés et du trèfle rouge semés en association montrent que l'utilisation d'une plante-abri récoltée à la maturité affecte considérablement la productivité des espèces fourragères l'année du semis et contribue à réduire le rendement de 13 % les années subséquentes. Bien que le rendement total soit plus élevé en présence des mauvaises herbes l'année du semis, l'établissement sans lutte contre les mauvaises herbes à feuilles larges occasionne des pertes de production de 30 % l'année suivante; ces pertes atteignent 15 % lorsqu'on ne lutte pas contre les mauvaises herbes de type graminées. Toutefois, au cours de la deuxième année d'exploitation, la présence des mauvaises herbes vivaces à feuilles larges compense pour les pertes observées l'année précédente. L'analyse de la dynamique des composantes botaniques montre que les populations de mauvaises herbes sont dominées par des espèces annuelles l'année du semis. Au cours de l'établissement, les mauvaises herbes de type graminées produisent autant de biomasse que les mauvaises herbes à feuilles larges lorsqu'elles se développent indépendamment les unes des autres. Cependant, lorsqu'elles croissent simultanément, les mauvaises herbes à feuilles larges dominent. Durant les années de production, les populations de mauvaises herbes sont dominées par les espèces vivaces à feuilles larges. La structure et l'évolution des populations de mauvaises herbes de type graminées ne sont pas affectées par les pratiques culturales étudiées mais le développement des populations de mauvaises herbes à feuilles larges est accéléré par la présence de l'orge tandis qu'il est retardé par l'établissement du trèfle rouge. Les résultats de cette étude indiquent également que la densité des mauvaises herbes utilisée de pair avec le recouvrement au sol des espèces cultivées et des espèces nuisibles permettrait de développer des équations afin de prédire les pertes de production causées par les mauvaises herbes.

Récolte et conservation

Séchage du foin. Des andains de fléole fraîchement coupés ont été reconstitués au laboratoire afin d'évaluer l'importance de huit facteurs sur le séchage du foin. Sept variables ont été fixées à l'intérieur des plages suivantes: la température de l'air (16,5 à 30,0 °C), le déficit de pression de vapeur (1,08 à 1,70 kPa), le vent (0,7 à 2,5 m/s), le rayonnement (0 à 975 W/m^2), le conditionnement (0 à 80 pliures/m), le degré de saturation du sol en eau (0 à 80 %) et la masse surfacique du fourrage (2 000 à 10 000 kg de matière sèche/ha). La huitième variable, la teneur en eau initiale du fourrage, n'était pas fixée mais seulement mesurée; elle a varié entre 60 et 85 % sur une base humide. Les résultats de cette étude indiquent que le taux de séchage est corrélé positivement avec le rayonnement et le déficit de pression de vapeur. Toutefois, il est corrélé négativement avec la masse surfacique (épaisseur des andains) et la teneur en eau initiale. Le montage expérimental permet l'évaluation rapide de nouveaux traitements pour conditionner le foin.

Simulation de systèmes de production. Des modèles mathématiques ont permis de simuler la croissance de la luzerne, les chantiers de récolte, le séchage et les pertes au champ, la manutention et la perte en entrepôt, et l'alimentation à un troupeau laitier, avec calcul des suppléments requis. La coupe directe de la luzerne, à une teneur en eau de 80 % et conservée avec de l'acide formique, a été comparée avec de l'ensilage de luzerne préfanée à une teneur en eau de 50 %. Des données climatiques de la ville de Québec (1967–1976) ont servi à simuler les deux systèmes sur une période de 10 ans. La coupe directe a permis de réduire les pertes aux champs de 9 %, et d'obtenir une meilleure qualité et des coûts annuels de suppléments moins variables qu'avec l'ensilage préfané. Cependant, le coût moyen des deux systèmes était sensiblement le même en raison du coût élevé de l'acide formique dont le seuil de rentabilité se situe présentement à un coût d'application de 4,50 $ par tonne de luzerne humide. Le système de coupe directe peut devenir plus favorable par une réduction des coûts d'entreposage. La coupe directe sera encore plus attrayante dans les régions à prédominance de graminées fourragères qui nécessitent moins d'acide que les légumineuses.

Évaluation de cultivars

Essais de cultivars de luzerne. L'évaluation de cultivars de luzerne pour le Québec s'est poursuivie en 1986 avec l'aide des stations coopérantes. Les cultivars DeKalb 135, Pioneer 526, Riel et Turbo ont été ajoutés à la liste des cultivars recommandés pour 1987.

Nouveau site en Abitibi-Témiscamingue. Tous les cultivars de luzerne, de trèfle rouge, de lotier, de fléole des prés, de brome, de dactyle et d'alpiste roseau recommandés pour le Québec en 1986 ont été ensemencés sur un site expérimental localisé à Évain, près de Rouyn. Cet essai a été entrepris afin de vérifier le comportement de ces espèces fourragères sous les conditions climatiques et édaphiques de la région de l'Abitibi-Témiscamingue.

LES CÉRÉALES

Amélioration génétique

Programme d'amélioration. Les efforts portent sur quatre espèces de céréales de printemps. En 1986, 32 % des travaux étaient consacrés au blé, 19 % à l'orge, 25 % à l'avoine et 24 % au triticale. L'intérêt grandissant des producteurs de la province pour un cultivar de blé d'alimentation humaine et un cultivar de triticale adaptés aux conditions du Québec justifie l'intensification de nos efforts pour l'amélioration génétique de ces deux espèces céréalières.

Performance du triticale. Depuis 1983, le triticale a été, dans l'ensemble, 19,5 % plus productif que les cultivars de blé Laval 19 et Mondor. De plus, le triticale n'était que 3,6 jours plus tardif que ces cultivars de blé. Une variabilité génétique évidente chez le triticale pour le rendement et la maturité a donc incité les manipulations qui ont permis 150 croisements en 1986. Les populations en ségrégation issues de ces croisements sont sélectionnées pour la qualité du grain, une paille de longueur intermédiaire et une maturité similaire à celle du blé.

Orge. Pour une troisième année consécutive, deux lignées d'orge ont été incorporées dans des essais d'enregistrement. Elles se caractérisent par des rendements supérieurs aux témoins et une paille plus forte. Ces lignées démontrent également une certaine tolérance à l'acidité et une adaptation aux conditions des provinces maritimes ce qui présage leur utilisation dans les rotations avec les pommes de terre.

Avoine. En 1986, quelque 98 croisements ont été réalisés pour combiner les gènes de nanisme aux gènes d'adaptation de nos meilleurs cultivars. Une très forte pression de sélection est exercée contre la stérilité des épillets causée par le dernier entre-noeud qui demeure court et qui empêche la sortie complète de la panicule.

Détermination des qualités panifiables du blé par la spectroscopie. En 1986, une étude a été entreprise afin de déterminer le potentiel de la spectroscopie par réflectance dans le proche infrarouge pour l'évaluation des qualités panifiables du blé. Une des principales retombées de cette étude sera de fournir une nouvelle technologie de sélection peu coûteuse et rapide pour le développement de cultivars de blé panifiable adaptés au Québec.

Croisements intergénériques. Le transfert au blé de la résistance au virus de la jaunisse nanisante de l'orge (VJNO) provenant du triticale, des agropyres et des elymes a été démontré. Cette résistance ne semble pas monogénique. Le succès de l'hybridation intergénérique demeure très bon, mais certains rétrocroisements sont plus difficiles que d'autres. C'est relativement facile de rétrocroiser au blé les hybrides à *Agropyron repens* ou à *Thinopyrum* sp., mais avec les *Elymus*, seules les espèces tétraploïdes ont pu être rétrocroisées. L'obtention de l'hybride *Hordeum jubatum* × blé a été confirmée.

Pathologie

Moisissures nivéales. La présence dans la nature de trois champignons responsables des moisissures nivéales chez les céréales d'automne a été confirmée. Ce sont le *Gerlachia nivalis*, le *Sclerotinia borealis* et le *Typhula ishikariensis*. Ces agents pathogènes se retrouvaient autant dans les parcelles expérimentales que dans des champs cultivés dans plusieurs régions de la province.

Tache helminthosporienne chez l'orge. Par une étude comparative en parcelles, la tolérance du cultivar d'orge Laurier à l'égard de la tache helminthosporienne causée par le *Bipolaris sorokiniana* a été mise en évidence. Les rendements de ce cultivar sont peu affectés lorsque l'intensité de la maladie est faible ou modérée et que ce n'est qu'au delà d'un certain niveau de symptômes que la productivité subit une baisse. Tout en ayant un niveau de symptômes équivalent à celui chez d'autres cultivars, l'orge Laurier a subi la diminution de rendement la plus faible.

Résistance au VJNO. Les résultats d'une étude confirment que le VJNO prédispose le blé tendre à plusieurs maladies fongiques, y inclus la fusariose. La résistance au virus est cependant génétiquement différente de la résistance aux maladies fongiques. Cette étude a permis, entre autres, de noter que le blé brésilien IAS-20, déjà déclaré résistant au virus, résiste également à la fusariose. Ces succès découlent de la collaboration avec le Centre international pour l'amélioration du maïs et du blé (CIMMYT, Mexique) et le Centre international de recherche agricole en région aride (ICARDA, Syrie), dans le cadre d'un projet du Centre de recherche et développement international (CRDI).

Évaluation de cultivars

Nouveau site en Abitibi-Témiscamingue. Dans le cadre des essais d'adaptation des cultivars de céréales recommandés pour le Québec, un nouveau site a été aménagé dans cette région. Plusieurs cultivars d'orge, d'avoine et de blé ont été évalués en parcelles sur ce site situé à Évain, près de Rouyn. Des essais d'enregistrement ont également été établis à cet endroit pour l'orge et l'avoine.

Épidémie de VJNO. Une épidémie de VJNO a atteint plusieurs regions du Quebec en 1986. Dans les parcelles du nouveau site d'évaluation à Évain, les deux cultivars d'avoine développés à la station et récemment enregistrés comme tolérants au virus, Nova et Cardinal, n'ont subi aucune perte significative de rendement dans cette épidémie naturelle tandis que les cultivars sensibles ont subi des pertes atteignant 50 %.

LES SYMBIOSES VÉGÉTALES

Fixation d'azote

Production massive de Rhizobium. Un milieu de culture à base de lactosérum, un sous-produit de l'industrie fromagère, pour la croissance du *Rhizobium meliloti* a été élaboré pour la production massive d'inoculants. Afin d'éliminer la période de latence causée par la synthèse de l'enzyme responsable de la dégradation du lactose, l'inoculum doit être préparé dans des conditions d'induction. Avec le milieu contenant du lactosérum, le nombre de bactéries produites atteint 5×10^9 CFU/mL après 48 heures de fermentation. Ce taux de production cellulaire est comparable à celui obtenu avec le milieu contenant du mannitol qui est habituellement utilisé pour la multiplication du *Rhizobium*. Toutefois, si de l'extrait de levure (1 g/L) et du phosphore (0,5 g/L) sont ajoutés au milieu à base de lactosérum, le nombre de bactéries produites atteint 1×10^{10} CFU/mL ce qui représente une augmentation du double du nombre de cellules viables sans affecter leur pouvoir de noduler. Le lactosérum représente un substrat peu dispendieux et prometteur pour la production massive de *Rhizobium*.

Souches de Rhizobium pour les haricots. Une étude a permis d'isoler 48 souches du *Rhizobium leguminosarum* biovar. *phaseoli* à partir de nodules de plantes d'haricots cultivées au Rwanda. La détermination de l'efficacité symbiotique de ces souches en serres indique que 19 %, 58 % et 23 % des souches se sont avérées très efficaces, efficaces et inefficaces respectivement. Grâce à l'action du bilan azoté, il est estimé qu'en présence d'une souche très efficace, 86 % de l'azote présent dans les tiges provient de la fixation symbiotique. Dans les essais de compétition, neuf souches efficaces se sont montrées très compétitives et deux souches inefficaces. Les résultats d'une seconde étude sur l'effet de l'inoculation avec différentes souches de *Rhizobium* isolées de sols du Québec sur le rendement et le contenu en azote du haricot jaune (*Phaseolus vulgaris* 'Goldie') montrent que les meilleurs rendements en matière sèche et en azote total sont obtenus avec 71 % des souches isolées. De plus, jusqu'à 74 % de l'azote contenu dans les gousses provient de la fixation symbiotique ce qui démontre l'importance de ce processus chez le haricot jaune.

Rhizobium pour le lupin. Sur 10 souches de *Rhizobium* testées, cinq ont montré une plus grande efficacité chez le lupin (*Lupinus albus*), tant par un rendement supérieur de matière sèche que par un indice nodulaire plus élevé. Les résultats indiquent également que certains cultivars de lupin offrent les caractéristiques désirées pour l'implantation du lupin protéagineux ou fourrager au Québec.

Inoculants commerciaux. En collaboration avec la Direction de la production et de l'inspection des aliments dans le cadre de son programme sur les inoculants des légumineuses, et en conformité avec les règlements de la loi sur les fertilisants, 34 inoculants commerciaux à base de *Rhizobium* et 16 échantillons de graines pré-inoculées ont été analysés. Les inoculants pour le lotier, la luzerne et les trèfles ont un taux de satisfaction aux normes légales de 100 %, 95 % et 100 % respectivement. La qualité pour les graines pré-inoculées de luzerne et de trèfle est de 64 % et 0 % respectivement; l'introduction d'un nouveau concentré de mauvaise qualité servant à la production des graines pré-inoculées a contribué à la mauvaise performance de ces produits.

Endomycorhizes

Isolement de champignons endomycorhiziens. Des 32 souches de champignons endomycorhiziens provenant de luzernières et de champs de céréales situés à La Pocatière, ainsi que de plantes indigènes récoltées à différents endroits, cinq nouvelles espèces ont été isolées pour le Québec : *Glomus aggregatum*, *G. caledonicum*, *G. fasciculatum*, *G. microaggregatum* et *G. mosseae*. Actuellement, une banque de 13 espèces de champignons endomycorhiziens préservés et en multiplication massive est disponible; quatre de ces espèces proviennent des États-Unis tandis que les neuf autres sont indigènes du Québec. Avec les espèces disponibles en quantité suffisante, des tests de comparaison d'efficacité chez la luzerne (*Medicago sativa* 'Saranac') ont démontré qu'après huit coupes, d'une culture en pots, le *Glomus versiforme* est le champignon le plus efficace à stimuler la production de biomasse. De plus, l'inoculation des deux symbiotes (endomycorhizes-*Rhizobium*) a contribué à un synergisme remarquable (+45 %) comparativement aux symbiotes endomycorhiziens (+23 %) et *Rhizobium* (+3 %).

Rhizobactéries

Rhizosphère du maïs. En 1986, une étude de la rhyzosphère du maïs a été entreprise afin d'isoler des bactéries ayant un synergisme marqué pour les plantes de cette espèce. Plus de 600 bactéries dont 10 % d'origine endoracinaires ont été isolées de plantes d'une vingtaine de cultivars de maïs dans différentes régions du Québec. Une première sélection, basée sur le poids sec d'une plante entière de maïs après 5 semaines de croissance en serres, a permis d'identifier des souches qui ont un effet marqué sur le développement de cette espèce.

LA SURVIE À L'HIVER

Test pour la tolérance au gel

Comportement des plantules de céréales. Depuis 1981, les efforts en vue de développer un test pour la tolérance au gel chez les céréales d'hiver ont progressé. Un test basé sur les jeunes feuilles primaires de l'orge, du blé, du seigle et de l'avoine a été mis au point; les jeunes feuilles primaires sont particulièrement tolérantes au gel et constituent un matériel de choix pour sélectionner des cultivars présentant de légères différences de tolérance. Le test est rapide et demande peu de travail. Les graines sont mises à germer dans des assiettes pendant 3 jours et les plantules sont endurcies dans ces mêmes assiettes à l'obscurité durant un mois à 3 °C. Par la suite, elles sont congelées à la température désirée et dégelées à 2 °C pendant quelques heures. Les tiges sont coupées et les jeunes feuilles primaires sont placées dans une solution nutritive pour mesurer la survie d'après leur verdissement et leur croissance à la lumière. Le test est suffisamment précis et donne un classement des cultivars comparable à celui observé au champ. Ce test sera utilisé avec d'autres espèces telles que le chiendent et l'élyme.

Dosage de l'acide abscissique. Une étude a été entreprise afin de déterminer, à l'aide d'un système de dosage radio-immunologique, les variations des niveaux d'acide abscissique (ABA) se retrouvant dans les tissus végétaux de cultivars de blé et de luzerne, différant par leur rusticité, lors d'une exposition au froid. Les résultats obtenus suggèrent que l'ABA joue un rôle d'induction dans les processus d'acquisition de la résistance au froid. En effet, tant chez le blé que chez la luzerne, les cultivars rustiques présentent des niveaux plus élevés d'ABA que les cultivars plus sensibles après leur endurcissement au froid. Chez le blé, une accumulation massive d'ABA se produit après quelques jours d'endurcissement au froid. De plus, après 2 semaines de traitement, l'ABA lié s'accumule chez le cultivar de blé sensible au froid ce qui laisse sous-entendre que les quantités résiduelles d'ABA libre ne soient plus suffisantes pour permettre un meilleur endurcissement.

Régulation des niveaux de polyamines. Des variations très importantes de polyamines sont observées lors de conditions de stress. Une étude a été amorcée afin de déterminer si ces composés jouent un rôle actif dans l'adaptation au froid du cultivar de blé Kharkov résistant au froid. Les résultats obtenus au laboratoire et au champ montrent que la putrescine augmente considérablement (de 6 à 8 ×) chez ce blé à la suite d'un endurcissement au froid. La spermidine augmente également mais d'un facteur de trois tandis que la spermine diminue légèrement. Bien que cette étude illustre les modifications se produisant dans les polyamines à la suite de l'exposition aux basses températures, il est difficile de déterminer si les polyamines agissent comme indicateurs de stress ou si ces composés sont directement impliqués dans les mécanismes de résistance au froid. Une meilleure connaissance des processus physiologiques et biochimiques qui se produisent lors de l'endurcissement au froid des plantes est à même de contribuer au développement de cultivars plus rustiques.

LES SOLS

Fertilisation

Phosphore et potassium chez l'avoine. L'effet de quatre doses de phosphore et de potassium sur les rendements de quatre cultivars d'avoine a été étudié en serres. Deux récoltes de grain ont été prélevées. Des différences de production ont été notées en fonction des doses de phosphore au cours des deux récoltes. Le potassium entraîne des différences de rendement à la deuxième récolte seulement. Le cultivar Lamar a donné les meilleurs rendements en grain aux deux récoltes avec 14,5 et 11,6 g/pot. Le cultivar Manic (12,2 g/pot) a été le moins productif à la première récolte et le cultivar Laurent (11,0 g/pot) à la deuxième.

Fumure azotée chez le soja. Des essais en serres et au champ ont démontré que les engrais azotés, appliqués à des doses atteignant jusqu'à 120 kg/ha de N, n'ont affecté que très peu le rendement en grain du soja; un maximum de gain de rendement de l'ordre de 500 kg/ha pour un rendement maximum dépassant 3 000 kg/ha a été noté avec le cultivar Maple Amber, cultivar précoce utilisé au Canada. Les meilleurs rendements en grain ont été obtenus à des doses d'azote variant entre 30 et 60 kg/ha. Les applications au semis ou à la floraison ont eu des effets similaires sur le rendement en grain lorsque le soja était cultivé au champ. Par contre, en serres, l'application des engrais azotés au moment de la floraison a permis d'obtenir un rendement en grain légèrement supérieur. La fumure fractionnée (au semis et à la floraison) ne s'est pas avérée meilleure que la fumure unique. Les teneurs en protéine et en huile de soja n'ont été que très peu influencées par la fertilisation azotée. Ces résultats suggèrent qu'une dose modérée d'azote peut être bénéfique pour la culture du soja au Québec.

Effet de l'azote, du cuivre et du zinc sur l'orge. Une expérience portant sur l'effet de trois doses d'azote, de cuivre et de zinc sur le rendement de l'orge cultivée sur un sol organique a été effectuée en serres. L'azote et le zinc n'ont pas entraîné d'augmentation significative de rendement en grain tandis que le cuivre a eu un effet très marqué. Avec une fertilisation exempte de cuivre, l'épiaison a été presque nulle et le rendement en grain a été de 0,12 g/pot seulement. Un apport de 5 mg/kg de Cu a permis d'obtenir un rendement de 2,77 g/pot; à cette dose, l'épiaison était meilleure mais un pourcentage élevé d'épis stériles a été noté. Le meilleur rendement en grain a été obtenu avec une dose de 10 mg/kg de Cu.

Physique et conservation

Stabilité structurale des sols argileux. Une proportion importante des sols cultivés au Québec sont argileux. Ces sols ont une structure fragile qui tend à se dégrader sous les effets de différentes contraintes telles que les fortes pluies, la machinerie lourde et la culture intensive. Cette dégradation des sols contribue ainsi à accentuer les problèmes fréquemment observés de compaction, d'érosion et de battance. Différentes mesures telles que la réduction du travail du sol, les amendements organiques ainsi que les rotations appropriées peuvent etre prises afin d'améliorer la stabilité de la structure des sols. Une étude a été entreprise cette année à La Pocatière afin d'évaluer les effets de différentes cultures sur la structure de l'argile Kamouraska, un sol susceptible à la dégradation structurale.

FERME EXPÉRIMENTALE, LA POCATIÈRE

Les plantes fourragères

Évaluation de cultivars. La Ferme expérimentale de La Pocatière est un des sites d'essai de cultivars de plantes fourragères au Québec et, comme à chaque année, plusieurs lignées et cultivars de légumineuses et de graminées ont été évaluées. Une section antérieure du présent rapport fait état des quatre cultivars de luzerne qui ont été ajoutés à la liste des cultivars recommandés pour 1987. De plus, le Comité des plantes fourragères du CPVQ a appuyé les demandes d'enregistrement de la luzerne LSC 214 et des lotiers Norcen et 01004.

Semence du trèfle rouge. En 1986, les rendements en semence des cultivars de trèfle rouge ensemencés sur l'argile Kamouraska ont été très faibles; la quantité de graines formées qui ont atteint la maturité a été minime car les conditions climatiques ont été défavorables à cette production.

Semis direct de raygrass. Les dommages importants aux prairies causent parfois aux éleveurs de sérieux problèmes d'approvisionnement en fourrage. Une étude a été entreprise afin d'implanter le raygrass annuel par un semis direct dans le but d'atténuer les effets néfastes d'une chute soudaine de la productivité d'une prairie. En 1986, le climat frais et les précipitations fréquentes ont favorisé l'implantation du raygrass. Le rendement saisonnier (3 récoltes) de la prairie rénovée a varié de 5 897 à 8 259 kg/ha selon les cultivars.

Horticulture

Amélioration de la pomme de terre. L'amélioration génétique de la pomme de terre s'est poursuivie à La Pocatière. Il y a eu pratiquement 11 000 lignées qui ont été évaluées au champ; de celles-ci 14 % ont été sélectionnées. Les lignées sélectionnées en 1985 à La Pocatière et à Fredericton ont été évaluées sur deux types de sol, Saint-André et l'Anse, au stade de 4 buttes. La sélection au champ a permis de conserver 29 % et 36 % de ces lignées pour les évaluations de rendement, densité relative, cuisson à l'eau et croustille. Les 235 lignées produites à La Pocatière et sélectionnées en 1985 ont été évaluées en parcelles sur trois sols différents, Saint-André, l'Anse et Saint-Pacôme, et 65 % de ces lignées ont été retenues. L'épuration de ces lignées pour la filosité et le flétrissement bactérien est en cours. Pour une troisième année consécutive, un essai de tamisage a eu lieu aux stations de Lennoxville, Normandin et La Pocatière; 54 lignées sélectionnées en 1985 ont été évaluées. Vingt et une lignées produites à La Pocatière ont été épurées et intégrées dans le réseau d'essais régionaux. Plusieurs de ces lignées ont également été évaluées dans les autres programmes canadiens d'amélioration.

Cultures fruitières et ornementales

Arbres fruitiers. Le rendement total des variétés de prunier a été beaucoup plus élevé en 1986 (960 kg) qu'en 1985 (421 kg) et 1984 (497 kg). Les variétés Stanley, Victoria, Mont-Royal, Damas Bleu et Reine-Claude ont produit des rendements de 31, 26, 26, 22 et 17 kg par arbre respectivement. Par contre, les variétés Miney, Menie et Clapps ont maintenu de bons rendements qui ont varié de 120 à 200 kg par arbre.

Arbres et arbustes ornementaux. Près de 2 500 arbres et arbustes sont évalués pour leur adaptation et leur résistance aux maladies. Bien que les 1 050 arbres transplantés en 1986 ont été affectés par les précipitations fréquentes, les plantations de 1984 et 1985 ont démontré une bonne croissance.

FERME EXPÉRIMENTALE, NORMANDIN

Les plantes fourragères

Mélange légumineuse-graminée. Les résultats d'un essai sur la productivité des cultivars de luzerne Saranac et de fléole Climax semés en mélange dans le même rang ou en rang alterné à des doses variant de 3 à 8 kg/ha indique que le rendement saisonnier (2 coupes) du mélange n'a varié que très peu en fonction des modes et des doses de semis. Toutefois, la contribution moyenne de la fléole au rendement du mélange a été plus élevée lorsque les espèces étaient établies en rang alterné.

Influence du chiendent sur l'établissement de la luzerne. Une première étude a démontré que la luzerne semée au printemps s'établit convenablement lorsque le chiendent est éliminé avant la troisième semaine suivant le semis. Une période d'interférence de plus de trois semaines tend à favoriser la population de chiendent au détriment de la luzerne et occasionne également une diminution de la qualité nutritive du fourrage. Dans une seconde étude, les densités élevées de chiendent ont réduit la croissance de la luzerne l'année du semis; environ 55 jours après la levée du semis, la population de chiendent avait contribué à réduire la surface foliaire, le poids racinaire et le poids de la partie aérienne de la luzerne. Le semis avec une plante-abri (avoine) permet cependant de réduire la croissance aérienne du chiendent l'année du semis et l'année subséquente.

Horticulture

Essais de cultivars de gourgane. Après 10 années d'évaluation, les rendements moyens des gousses vertes des cultivars Arnaud, TR-N, GI-N, Vainqueur et Grosse de Windsor n'ont varié que très peu; ils étaient de 15 951, 15 249, 15 792 et 16 013 kg/ha respectivement. Toutefois, les rendements moyens de grain vert ont été de 6 470, 6 011 et 6 349 kg/ha pour les cultivars Arnaud, TR-N et GI-N respectivement tandis qu'ils ont été de 4 434 et 4 943 kg/ha pour les cultivars Vainqueur et Grosse de Windsor. Les proportions de la gousse entière occupée par les grains verts, une caractéristique qu'il faut considérer dans l'évaluation de cultivars de gourgane, étaient de 42,1 %, 38,4 %, 37,7 %, 32,4 % et 28,6 % pour les cultivars GI-N, Arnaud, TR-N, Grosse de Windsor et Vainqueur respectivement.

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Départs

M. D. Bagnara, B.Sc.(Agr.), Ph.D. Démission, 19 décembre, 1986	Génétique
M. A. Conti, Doctorat d'Etat (Italie) À la retraite, 22 décembre, 1986	Chimie
M. M. Trudelle, B.Sc.(Agr. Eng.), M.Sc. Démission, 1er août, 1986	Hydrologie

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INTRODUCTION

La Station de recherches de Saint-Jean-sur-Richelieu sert l'industrie horticole en recherche sur la production et la protection regroupées en programmes multidisciplinaires: arbres fruitiers, petits fruits, légumes et fines herbes. Quelques travaux de recherches sont aussi effectués sur le maïs et les oléagineux. Les disciplines scientifiques représentées à la station sont : l'entomologie, l'acarologie, la phytopathologie, la nématologie, la chimie des pesticides, la toxicologie, le génie génétique, la fertilité, le génie aéronautique et la mécanique. La Ferme expérimentale de l'Assomption est reliée administrativement à la station et poursuit des travaux sur l'amélioration du maïs – grain, sur la sélection de cultivars et la gestion de la culture du tabac et de la rose et aussi sur la gestion des plantes ornementales.

Ce rapport résume quelques-unes des réalisations de la station en 1986 dont on trouvera les expériences plus détaillées dans les articles publiés durant l'année. Pour plus d'informations, veuillez vous adresser à: Station de recherches, Direction générale de la recherche, Agriculture Canada, C.P. 457, Saint-Jean-sur-Richelieu, Québec J3B 6Z8; Tél. (514) 346-4494.

C.B. Aubé
Directeur

CULTURES FRUITIÈRES

Action de trois gelées printanières sur les pommiers en 1986

L'action destructive de trois gelées printanières sur le rendement de quatre cultivars de pommiers a été étudiée en 1986. Les premières gelées se sont produites les 3 et 4 mai au stade du bouton rose des pommiers McIntosh tandis que la troisième gelée du 7 juin s'est attaquée aux jeunes fruits qui avaient échappé aux deux premières gelées.

Le plus fort pourcentage de nouaison s'est manifesté chez les cultivars les plus hâtifs et les plus rustiques comme le Melba et le Lobo et il y a eu plus de dommages dans la parcelle située à 94 m du niveau de la mer que dans celle à 115 m.

Chez les cultivars McIntosh et Cortland, les dommages ont été sensiblement les mêmes aux deux niveaux. La troisième gelée s'est avérée beaucoup plus destructive que les deux premières. Le cultivar Lobo a eu le plus grand nombre de pistils gelés mais il a quand même donné le plus fort pourcentage de fruits noués et non-affectés par le froid que les autres cultivars. Le cultivar Cortland, bien qu'il ait obtenu le plus fort pourcentage de fruits noués après les deux premières gelées, a été le plus sévèrement affecté par la troisième gelée.

Utilisation du piège Multi-pher^R en vergers de pommiers

Nous avons comparé le piège Pherocon 1C à trois modèles de piège Multi-pher, soit les modèles I, II et III. La différence entre ces modèles de piège est attribuable à la couleur et aux ouvertures du piège.

Selon les captures obtenues, on a pu classer les six vergers comme étant faiblement, moyennement et fortement infestés. Dans les vergers à faible niveau de captures, les pièges englués, Phérocon 1C et Vineland, se sont avérés plus efficaces que les pièges Multi-pher. Dans les quatre autres vergers, les pièges Multi-pher étaient supérieurs aux pièges collants. Ceci est dû au fait qu'à des niveaux élevés de capture, les pièges englués se saturent rapidement. On a ainsi estimé que les niveaux de saturation des pièges Vineland et Phérocon 1C sont respectivement de 300 et 1500 mineuses/piège. Les pièges Multi-pher ne sont saturés qu'après 500 000 individus capturés. La qualité des spécimens obtenus dans le piège Multi-pher est excellente, i.e. les insectes ne sont pas déformés et ceci facilite l'identification des spécimens. Enfin, le coût d'utilisation des pièges Multi-pher est relativement avantageux.

Signalons enfin que nous avons effectué des essais de dépistage chez plusieurs autres espèces de ravageurs et que l'analyse préliminaire des résultats a révélé que le piège Multipher est un bon outil de dépistage en vergers de pommiers.

Gestion du framboisier

Les cultivars Festival et Killarney se sont montrés nettement plus productifs que Newburg. Au niveau de l'entraînement, le rang conventionnel avec tiges fixées sur fils de fer a donné les plus forts rendements suivi de près par le système de production par alternance. Ce dernier système semble très intéressant compte tenu que la taille peut être complètement mécanisée. Même si le système de production bisannuelle comporte des économies certaines pour l'entretien, les rendements semblent beaucoup trop réduits pour en justifier l'utilisation. Les rendements beaucoup plus bas obtenus du système conventionnel sans fil sont surtout attribuables au bris de tiges et à la chute des fruits.

Fumigation pour le contrôle du nématode des lésions dans une framboiseraie

Le nématode des lésions *Pratylenchus penetrans* est un ravageur des cultures de petits fruits au Québec. En parasitant les racines de ces cultures, il rend difficile l'établissement d'une nouvelle plantation et réduit la production de la culture pour plusieurs années.

Des traitements de préplantation au fumigant ont été évalués dans une ancienne framboiseraie hébergeant des populations élevées de ce nématode. Les traitements au Vorlex et au Telone II-B ont permis d'accroître la vigueur et la productivité des framboisiers.

Il semble que le Vorlex soit plus efficace que le Telone II-B sous les conditions de cette expérience. À partir des augmentations de rendement enregistrées en 1985, on a établi que les coûts encourus par la fumigation (avec un traitement au Vorlex 180 L/ha) sont couverts plus de 10 fois dès la première année de production. Il semble aussi que la croissance accrue des parcelles traitées soit reliée au seul contrôle du nématode et non à l'élimination d'aucune autre maladie du sol.

Essai de cultivars et sélections de bleuetiers

Bleuetier nain. Deux essais sont en cours avec ce type de bleuetier à Frelighsburg. Dans le premier, les plants ont été mis en place en 1979. Depuis 1981, ils ont rapporté tous les ans, excepté pour 1985 parce qu'une taille a été effectuée. Dans le second essai, la plantation a été faite en 1981 et ces plants ont rapporté en 1984 et 1985. Quoique les rendements soient plutôt variables d'une année à l'autre, il appert que les cultivars et les sélections suivants sont les plus productifs: CHIGNECTO, BLOMIDON, 70-27, 51, 7-21 et NB-3.

Bleuetier en corymbe. Les cultivars de bleuetier en corymbe plantés en 1972 ont maintenant rapporté 11 récoltes commerciales de 1975 à 1986. Au cours des dernières années, l'ordre des cultivars a peu changé en ce qui a trait aux rendements cumulés. Comme pour les autres petits fruits, les rendements de 1986 ont été d'environ la moitié des rendements normaux, à cause des gels printaniers. Parmi les sept cultivars de cette plantation, Blueray, Berkeley et Bluetta sont les plus intéressants tant pour leur productivité que pour le calibre de leurs fruits et la période de récolte.

CULTURES MARAÎCHÈRES

Évolution de cinq désordres du chou d'hiver en entrepôt

Cinq désordres physiologiques du chou d'hiver (*Brassica oleracea* var. *capitata*) ont été étudiés du point de vue histologique durant une période de 149 jours de conservation en milieu réfrigéré (1 °C, 95 % HR). (1) La bigarrure nervale (vein streaking), (2) la griselure du limbe (grey speck disease) et (3) la moucheture noire (black speck) ont toutes affecté l'épiderme, mais en des sites initiaux distincts, soit respectivement (1) les cellules au sommet de plis sur la nervure adaxiale, (2) les cellules du limbe contigues aux nervures abaxiales et (3) les cellules stomatiques au centre du limbe. La médiane noire (black midrib) et la tache nécrotique (necrotic spot) ont débuté dans le parenchyme sous-épidermique, respectivement dans les nervures ou dans tous les tissus, et sous forme de cellules éparses causant du noircissement tissulaire massif ou sous forme d'îlots définis de cellules formant des taches épidermiques déprimées et équidistantes. Pour tous ces désordres, les premiers signes de dommages sont apparus sous forme de vésicules cytoplasmiques incolores et de noircissement du noyau et des angles des parois. Ensuite, des dépôts d'origine phénolique ont été notés sur les parois et les vésicules sont devenues brunes. Dans le cas de la médiane noire, elles étaient plus grosses pouvant occuper jusqu'à 1/5 de la cellule. La présence de polysaccharides acides non complexifiés a été notée dans les parois des cellules avoisinant les cellules malades.

Chou résistant à la hernie des crucifères

Un chou développé à la station a été récemment nommé «Richelain». Ce chou a un fort système radiculaire et résiste aux races 2, 6 et 7 du pathogène *Plasmodiophora brassicae* Wor. causant la hernie des crucifères. La pomme est assez compacte, de forme plutôt globulaire. La coloration externe est bleue et interne, blanche. Le diamètre vertical moyen de la pomme est de 17 cm et son poids est d'environ 2 kg. Ce chou est destiné surtout au marché frais.

Prédiction de l'apparition de la mouche de l'oignon par les degrés-jour et les mauvaises herbes

La mouche de l'oignon a trois générations au Québec mais la troisieme est peu abondante et represente probablement une génération partielle. Les premieres captures de la generation hivernante, de la premiere et de la deuxième génération se sont produites respectivement à 244,5 ± 13,6, 1047,3 ± 12,5 et 1778,5 ± 9,0 DJ 4 °C, lorsque ces degres-jour sont calcules à partir du 1^er^ avril. Les mauvaises herbes *Barbarea vulgaris* et *Epilobium angustifolium* peuvent respectivement servir d'indicateurs phénologiques pour les premieres captures de la génération hivernante et de la premiere génération. Ces plantes fleurissent environ 70 DJ 4 °C avant les premieres captures d'adultes ce qui donne un preavis utile. Le 50 % des captures pour les trois generations de mouche de l'oignon est survenu respectivement a 547,5 ± 97,1, 1343,3 ± 134,7 et a 1922,3 ± 58,7 DJ 4 °C. Les periodes de floraison du *Silene cucubalus* et du *Chrysanthemum leucanthemum* peuvent servir d'indicateurs phénologiques du 50 % de captures des adultes de la génération hivernante avec environ 100-150 DJ 4 °C, soit de 7 à 9 jours d'avance. La floraison de l'*Eupatorium maculatum* survient tout juste avant le 50 % de captures des adultes de la première génération.

TABAC

La production du tabac jaune en cellules de Todd

Durant 4 ans, on a etudie la production de plantules de tabac en cellules de Todd. Les traitements comprenaient quatre milieux de culture et quatre programmes de fertilisation. Chaque combinaison de milieu et de programme de fertilisation était évaluee en serre non chauffée et en serre chauffée. Il y avait aussi un témoin qui consistait en un semis conventionnel. Les plantules issues de ces traitements étaient ulterieurement évaluées en champs.

Le milieu de culture, terre noire bien décomposée contenant un peu de sable mais sans argile, a permis de produire la meilleure qualité de plantules en serre. Le programme de fertilisation NPK, 15-30-15, applique au besoin a la frequence de trois arrosages consecutifs a une concentration de 10 g/100 L, suivi d'un arrosage a l'eau, s'est avere le plus interessant. Les plantules produites en serre chauffée ont manifeste une croissance superieure a celles produites en serre non chauffée.

En champs, les plantules provenant des cellules de Todd ont donne un rendement plus élevé. De plus, leur floraison a été accelerée de 3 jours. Ces résultats indiquent que dans la région Lanaudière, l'usage d'une serre chauffée est essentielle pour la production de plantules en cellules de Todd. Leur utilisation en champ augmente la hâtivite des plants, le pourcentage de reprise et l'uniformite de la plantation. De plus, le rendement et le revenu brut sont superieurs.

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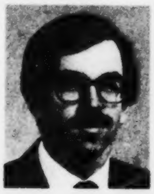
Ontario Region
Région de l'Ontario

J.J. Cartier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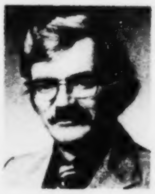
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Director General *Directeur général*	J.J. Cartier, B.A., B.Sc., Ph.D.
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PREFACE

The Ontario Region, with headquarters in Ottawa, consists of the three research stations at Harrow, Delhi, and Vineland; the London and Food research centres; and the three experimental farms at Smithfield, Kapuskasing, and Thunder Bay. When the Research Branch was reorganized, the Ottawa Research Station and the Animal Research Centre were transferred to the Central Experimental Farm Directorate. The Ottawa Research Station was amalgamated with the Chemistry and Biology Research Institute, to create the Plant Research Centre. Consequently, the region incurred a staff reduction, from the previous 850 to the current 390 (of which 123 are professional), and now operates with a budget of about $24 million. Each of the eight responsibility centres has specific mandates that address current and anticipated problems of concern to the agri-food industry.

The Harrow Research Station, being located in climatically the most favored area of Ontario, has a diverse research program. Its program features field crops such as corn, soybeans, winter wheat, and field beans, as well as horticultural crops such as tree fruits and vegetables, including greenhouse crops. Multidisciplinary research and development (R&D) activities are aimed toward developing new varieties, generating appropriate crop husbandry practices, and devising efficient integrated pest management technologies for the control of insects, diseases, and weeds. Harrow has also recently acquired responsibility for the technology evaluation and development sub-program of the federal–provincial southwestern Ontario soil and water quality enhancement program.

The Delhi Research Station is developing varieties and technologies for production and protection to serve the Canadian tobacco agri-industries in Ontario, Quebec, and the Maritimes. With the current declines in tobacco, the Delhi Research Station is reorienting resources toward developing alternate crops suitable for the sandy soil belt of the area, in order to broaden the agricultural base and protect the productivity.

Research at Vineland focuses on integrated pest management for orchard and vegetable crops; grapes and ornamentals; some forage crops; and mushrooms. The R&D programs aim to reduce the use of chemical pesticides while achieving the most effective control of pests, thereby increasing productivity and ensuring the high quality and safety of the crops. A multidisciplinary approach is adopted in the use of biotic factors, in collaboration with the provinces. The station also maintains a virus-free nuclear stock repository of strawberries, raspberries, and tree fruits. The Smithfield Experimental Farm conducts breeding research in apples and tomatoes and crop management research in orchard and vegetable crops, as well as some produce-processing research. Pest monitoring in orchards is utilized in the integrated pest management program.

The Kapuskasing Experimental Farm works with the Animal and Plant research centres of the Central Experimental Farm Directorate in developing improved beef production systems for northern Ontario and western Quebec, utilizing locally produced feeds. The Thunder Bay Experimental Farm evaluates the adaptation of forage, grain, and horticultural crops to the area and maintains virus-free potato tuber stocks.

The London Research Centre concentrates on research in integrated pest management and environmental toxicology and quality. The R&D activities of the centre aim to reduce the dependence of the agri-food industry on chemical pesticides and to ensure that the environmental and human health risks with regard to pesticides are minimized.

The Food Research Centre assists the Canadian food industry to become more competitive by developing new processes and prototype ingredients and by improving the quality, safety, and nutritive value of food. The research programs on processing technology, dairy technology, structure and sensory evaluation of food, and food safety and nutrition are geared to the needs of the food industry and the concerns of the consumers.

Detailed information on the various programs may be obtained by writing to the establishments concerned or by addressing inquiries to the Research Branch Headquarters, Agriculture Canada, Central Experimental Farm, Ottawa, Ont. K1A 0C5; Tel. (613) 995-7084.

J.J. Cartier
Director General

PRÉFACE

La Région de l'Ontario, dont l'administration centrale se trouve à Ottawa, comprend les stations de recherches de Harrow, de Delhi et de Vineland; le Centre de recherches de London et le Centre de recherches sur les aliments; les fermes expérimentales de Smithfield, de Kapuskasing et de Thunder Bay. Au moment de la réorganisation de la Direction générale de la recherche, la gestion de la Station de recherches d'Ottawa et du Centre de recherches zootechniques a été confiée à la Direction de la Ferme expérimentale centrale. La fusion de la Station de recherches d'Ottawa et du Centre de recherches chimiques et biologiques a donné naissance au Centre de recherches phytotechniques. Par conséquent, la région a subi une réduction de personnel, ses effectifs passant de 850 à 390 (dont 123 professionnels) et elle fonctionne maintenant avec un budget d'environ 24 millions de dollars. Chacun des huit centres de responsabilité a maintenant le mandat particulier de répondre aux difficultés actuelles et prévues d'intérêt pour le secteur agro-alimentaire.

La Station de recherches de Harrow, située dans la partie de l'Ontario jouissant des conditions climatiques les plus favorables, mène divers travaux. Son programme porte sur de grandes cultures comme le maïs, le soja, le blé d'hiver et le haricot, ainsi que sur des cultures horticoles comme les fruits de verger et les légumes, notamment les cultures de serre. Les activités pluridisciplinaires de recherche et de développement (R&D) sont axées sur la création de nouvelles variétés, la mise au point de pratiques culturales appropriées et de techniques efficaces de lutte intégrée contre les insectes, les maladies et les mauvaises herbes. Récemment, la Station s'est vue confier la responsabilité du sous-programme d'évaluation et de développement technologique dans le cadre du programme fédéral-provincial d'amélioration de la qualité des sols et de l'eau dans le sud-ouest de l'Ontario.

Les chercheurs de la Station de Delhi créent des variétés et mettent au point des techniques de production et de protection destinées à promouvoir l'essor du secteur canadien du tabac en Ontario, au Québec et dans les Maritimes. À cause du fléchissement actuel de ce secteur, la Station a réorienté ses ressources vers le développement de cultures de remplacement susceptibles de s'adapter à la ceinture de sol sablonneux de la région, afin d'élargir la base agricole et de conserver la productivité de cette région.

Les chercheurs de la Station de recherches de Vineland concentrent leurs efforts sur la lutte intégrée contre les ravageurs des cultures de vergers et des productions maraîchères; sur le raisin et les plantes ornementales; sur quelques cultures fourragères et sur les champignons. Les programmes de recherche et de développement visent à réduire l'épandage de pesticides chimiques, tout en luttant le plus efficacement possible contre les ravageurs en accentuant la productivité et en garantissant des cultures de haute qualité et sûres. Ici encore, de concert avec les provinces, on a adopté un mode pluridisciplinaire de recherche sur l'utilisation des facteurs biologiques. La Station conserve en outre du matériel génétique de fraisier, de framboisier et d'arbres fruitiers exempt de virus. Les chercheurs de la Ferme expérimentale de Smithfield s'adonnent à des travaux de sélection de la pomme et de la tomate et à des recherches sur les pratiques culturales appliquées dans les vergers et dans les cultures maraîchères. Certains travaux portent également sur les méthodes de transformation des fruits et des légumes frais. Par ailleurs, dans les vergers, on essaie des méthodes de lutte intégrée contre les ennemis des végétaux.

La Ferme expérimentale de Kapuskasing collabore avec le Centre de recherches zootechniques et le Centre de recherches phytotechniques de la Direction de la Ferme expérimentale centrale à la mise au point de systèmes améliorés d'élevage de bovins de boucherie pour le nord de l'Ontario et l'ouest du Québec, en utilisant des aliments pour bestiaux produits dans la région. Les chercheurs de la Ferme expérimentale de Thunder Bay évaluent le degré d'adaptation des cultures fourragères, céréalières et horticoles dans la région et conservent des souches de pomme de terre exemptes de virus.

Le Centre de recherches de London concentre ses efforts sur la lutte intégrée contre les ravageurs, et sur la toxicologie et la qualité de l'environnement. Ses activités de recherche et de développement visent à diminuer la dépendance du secteur agro-alimentaire vis-à-vis les pesticides chimiques et à réduire au minimum les risques que ces produits comportent pour l'environnement et la santé humaine.

Pour leur part, les scientifiques du Centre de recherches sur les aliments aident le secteur alimentaire canadien à devenir plus compétitif par la mise au point de procédés, la création d'ingrédients innovateurs et l'amélioration de la qualité, de l'innocuité et de la valeur nutritive des aliments. Les programmes de recherches sur la technologie de la transformation, sur la technologie laitière, sur la structure et l'analyse sensorielle des aliments, ainsi que sur l'innocuité des aliments et la nutrition doivent répondre aux besoins du secteur alimentaire et aux préoccupations des consommateurs.

Pour obtenir de plus amples renseignements sur les divers programmes, il faut écrire aux établissements concernés ou adresser ces demandes à l'Administration centrale de la Direction générale de la recherche, Agriculture Canada, Ferme expérimentale centrale, Ottawa (Ontario) K1A 0C5. On peut également téléphoner au (613) 995-7084.

J.J. Cartier
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Departures

D.F. Wood, B.Sc., M.Sc., Ph.D. Resigned	Meat processing
B. Picard, B.Sc., M.Sc., Ph.D. Resigned	Microbial biochemistry

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[1] Maternity leave.

[2] Educational leave, University of Maryland, Beltsville, Md.

INTRODUCTION

The aim of the Food Research Centre (FRC) is to assist Canada's food and beverage industry in becoming more efficient, productive, and competitive by developing new and improved processing technology and ingredients, and by improving the quality, safety, and nutritional value of food. The primary clients of the centre are food and beverage processing companies and associations, other branches of Agriculture Canada, and other government departments. The Food Research Centre provides research services and advisory services; it also manages research contracts and grants. The staff members of the centre represent the branch, the department, and the country as a whole at national and international meetings.

The centre's staff make a significant contribution to the expert committees of the Canada Committee on Food. In addition, scientists participate in the international food programs of Codex Alimentarius, the International Dairy Federation, the Food and Agriculture Organization (FAO), and the International Consultative Group on Food Irradiation.

More emphasis is being placed on technology transfer to industry and government clients, promotion of collaborative research projects, and improved mechanisms to ensure participation by the private sector in FRC research activities.

The scientific and technical contributions of Dr. D.B. Emmons and Dr. V.R. Harwalkar were recognized in 1986. Dr. Emmons received Agriculture Canada's Merit Award for his contribution to the development of Canada's dairy industry. Dr. Harwalkar received the Pfizer Inc. Award from the American Dairy Science Association for his research on cheese and cultured dairy products.

This report provides highlights of research activities in 1986. Publications and more information can be obtained by writing to the Food Research Centre, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6; Tel. (613) 995-5362.

N.W. Tape
Director

PROCESSING TECHNOLOGY

Oat starch

Oat starch has been chemically modified by esterification with phosphate to give a PO_4 content of 0.90%. Corn and wheat starches esterified by the same procedure gave a PO_4 content of 0.69 and 0.67%, respectively. The much smaller granule size of oat starch results in a much larger available surface area per unit weight of starch and is a likely explanation for the higher degree of esterification. At 3.5% w/w solids concentration, oat starch phosphate was three times as viscous as the unmodified control and 50 and 40% greater, respectively, than wheat and cornstarch phosphates. All starch phosphates exhibited freeze–thaw stability of at least five cycles and were thus typical of commercial products. Cross-linked and acetylated oat, wheat, and corn starches did not form gels but produced stable, spoonable pastes. Oat starch, thus modified, exhibited a viscosity 50% greater than that of modified cornstarch when analyzed at 5 rpm at 25°C using a Brookfield Viscometer (Model RVT) and a No. 5 spindle but showed extreme sensitivity to shear.

Oat starch contains up to 1.5% w/w of internally bound lipids. When heated with water, a strong amylose-lipid complex is formed as determined by differential scanning calorimetry (DSC). Removing this lipid does not produce a complex, and indeed the resultant starch forms an aqueous gel which is firm, opaque, and behaves similarly to other cereal starch gels. Adding back the extracted lipid to the extracted starch results in a product having quite a different DSC response to the native starch and a rheology that is more salvelike than gel-like. The mechanism of lipid reabsorption and subsequent complexation with oat starch amylose is believed to be fundamentally different. Application of the Flory-Huggins equations, based on the theory of polymer melting, to oat starch suggests that the latter is more amorphous and less ordered than the starch of wheat or corn. These data are consistent with previous findings of amylose and amylopectin coleached from oat starch granules, contrary to the behavior found for other cereal starches. A reappraisal of the storage behavior of aqueous starch pastes using DSC clearly demonstrates that all starch pastes recrystallize or retrograde but that the initial rate of recrystallization for oat starch is 50% that of the starch of wheat or corn. Over a 30-day storage period, oat starch tends towards the same limit value for recrystallization as wheat or corn. These data provide further evidence for the role of internally bound oat starch lipids and the contribution these make to improving the storage of aqueous oat starch pastes via starch complexation.

Cereal β-glucans

Oat β-glucan prepared in the laboratory using bucket centrifuges has a molecular weight (as estimated by high-performance gel chromatography) of 7×10^6 compared with about 2.5×10^6 for pilot plant prepared material. This change arises from shear forces encountered in pilot plant centrifuges, which bring about significant losses in viscosity. Such viscosity losses have also been observed in samples subjected to high-speed blending and sonification.

Coarse and fine fractions obtained from oats by a number of different procedures have been analysed for β-glucan. Coarse fractions derived mainly from the outer layers of the kernel contained up to 19% β-glucan, and inner endosperm flour contained 0.6–0.9% β-glucan. Oat hulls contained 0.2% β-glucan, probably from contaminating endosperm.

Analysis by high performance liquid chromatography (HPLC) of oligosaccharides released by a (1→3)(1→4)-β-D-glucan-4-glucanohydrolase have demonstrated distinctive differences in the fine structure of oat, barley, and wheat β-glucan and lichenan.

In feeding trials with rats conducted in collaboration with Laval University and the University of Kentucky, oat gum (80% β-glucan) decreased postprandial insulin but not serum glucose and reduced total serum and liver cholesterol and serum low density lipoprotein cholesterol.

Cereal phenolics

Structural characterization of alcohol-soluble, bound phenolics in oat grains has revealed several classes of biologically active constituents. Group fractionation of oat phenolics by ion-exchange and gel filtration chromatography produced anionic, cationic, and neutral phenolic fractions. From the anionic fraction a series of alkaloids, trivially named avenanthramides, has been isolated. The avenanthramides, of which over 25 different components have been distinguished, consist of the *N*-feruloyl, *N*-caffeoyl, and *N*-*p*-coumaroyl conjugates of anthranilic and hydroxy–methoxy anthranilic acids. Recent research in Japan has shown that the *N*-cinnamoyl anthranilates possess potent antihistaminic and antiinflammatory activity.

The neutral phenolic fraction was found to contain steroid and triterpenoid saponins acylated with phenolic acids. The relatively rare aminophenolic acids, anthranilic and *N*-methylanthranilic acids, were identified from hydrolyzates of these saponins although the exact nature of the aglycones has not been elucidated. Preliminary studies have shown that the aminoacyl functions are attached to the aglycone rather than the sugar moiety and thus are similar to, if not identical with, the potent antifungal avenacins. These unusual ester saponins are surfactants and are at least partly responsible for the observed stability of oat lipid emulsions.

The cationic fraction contained a series of glycosidically bound 2-aminophenol derivatives. The smallest member of the series has been identified as 2-amynophenoxy-1-*O*-β-D-glucopyranoside by nuclear magnetic resonance and mass spectral studies and confirmed by synthesis. The aglycone 2-aminophenol is unstable in air, auto-oxidizing to give a dimer, questiomycin B, possessing antibiotic activity.

Oat protein

Oat protein isolates were modified by deamidation (mild acid hydrolysis) and carboxyl modification. Fat binding and emulsifying properties were significantly improved by deamidation, whereas water hydration capacity was increased by both modifications. Deamidated oat isolates had good gel-forming ability, producing gels with excellent water-holding capacity and rheological properties when mixed with egg white at up to 1:1 ratio. This indicates that the modified protein may have potential as an egg-white substitute.

The effects of salts, reducing agents, denaturants, and water miscible solvent on thermal gelation of oat globulin were studied to determine the mechanism and molecular forces that operate in the gelation process. Results suggest that stabilization of the three-dimensional gel structure may involve hydrogen bonding, as well as hydrophobic and electrostatic interactions, with disulfide linkage and thiol-disulfide interchange playing lesser roles. Some fatty acid salts were found to be effective in lowering heat stability and promoting gelation of oat proteins near neutral pH, under conditions more suitable for food applications.

Food irradiation – poultry

The efficacy of food irradiation (cobalt-60) for the control of salmonella in chicken was investigated under commercial conditions. Chicken parts and mechanically separated chicken meat (MSCM) inoculated with *Salmonella typhimurium* (NAL+) at unrealistically high levels (10^4 colony-forming units per gram and 10^2 colony-forming units per gram were irradiated in a frozen state at 2.4–2.5 kGy.

Irradiation of fresh or frozen samples resulted in the elimination of salmonella. Inoculated samples showed a significant reduction, as much as 5 logs in most cases. *Escherichia coli* were successfully eliminated by irradiation, as were the naturally occurring *Staphylococcus aureus*. The shelf life of fresh chicken parts and MSCM was extended from the normal 5–6 days to 11–12 days. Irradiation did not affect the chemical indices examined, such as thiobarbituric acid (TBA) values, proximate analysis, and free moisture. Sensory evaluation of products prepared from irradiated chicken, (weiners, sausages, patties), did not show any undesirable flavor.

Frozen turkey halves, subjected to ionizing radiation (cobalt-60) at average doses of 3 and 6 kGy were evaluated for sensory quality. Forty-eight panelists evaluated the white and dark irradiated turkey meat as compared with nonirradiated controls. No significant difference ($P = 0.05$) was noted in the sensory quality, cooking characteristics, and appearance, except that at doses of 6 kGy the white meat showed slight pink discoloration in the raw and cooked samples.

DAIRY TECHNOLOGY

Heat resistance of *Listeria*

An outbreak of listeriosis in Massachusetts in 1983 prompted investigators to question the efficacy of pasteurization in the control of *Listeria monocytogenes*. Experiments to determine the resistance of 10 strains of *L. monocytogenes* to pasteurization temperatures ranging from 60 to 72°C for 16 s were carried out in the FRC pilot plant. The organisms survived temperatures of up to 67.5°C but could not survive pasteurization at 72°C. Milk that was naturally contaminated with *L. monocytogenes* was also treated and found to contain no viable organisms after pasteurization.

Alkaline phosphatase in butter and cream

Laboratories routinely screening for alkaline phosphatase (AP) in butter have reported difficulties with false positives resulting from reactivation of AP. When butter samples manufactured from 32% cream pasteurized at 85°C for 16 s were melted at 40°C in order to obtain serum for analysis, reactivation of AP was observed. The addition of solid butter samples to assay buffer prewarmed to 40°C prevented reactivation, since the pH of the buffer (9.2) was higher than the optimum for reactivation (6.8). Ethylenediaminetetraacetic acid (EDTA), a metal ion chelator, was also used to prevent reactivation in cream samples that were temperature abused before analysis.

Functional properties of whey proteins

The effects of covalent acylation of β-lactoglobulin with fatty acids were studied with a view to obtaining protein of improved functional properties. The lipophilized protein became more electronegative during polyacrylamide gel electrophoresis (PAGE). The increase in chain length of fatty acid reduced the staining ability of the modified protein. Differential scanning colorimetry (DSC) study showed that the transition temperature (T_d) and enthalpy of denaturation decreased when β-lactoglobulin was derivatized with C_6–C_{12} fatty acids indicating loss of stability and structure. C_{14} derivative of β-lactoglobulin showed no response at seven equivalent substitution, but at 14 equivalent substitution indicated regaining of structure as seen by a DSC peak. The C_{16} and C_{18} derivatives were more heat stable as indicated by the higher T_d. The lipophilized β-lactoglobulin was not readily soluble in water but would be dispersed by sonification. These dispersions at 5% protein when heated at 97°C for 5–10 min remained in suspension, but when heated in the presence of glucono-δ-lactone (GDL) they gelled with varied microstructure.

Genetics of lactic acid bacteria

In lactic streptococci, lactose metabolism has been clearly established as being plasmid mediated. Lactose-negative variants missing such a plasmid molecule when incubated in a growth medium for 72–96 h at 20–32°C showed the appearance of partial lactose-fermenting revertants. Such revertants grew slowly and coagulated milk after 16–24 h of incubation at 32°C, as opposed to a lactose-fermenting parental strain, which coagulated milk after 6–8 h of incubation.

Strains devoid of plasmid DNAs also showed reversal to partial lactose-fermenting type. This ability of partial lactose-fermentation was transferable by conjugation. Furthermore, the phenotypic characteristic was quite stable under different growth conditions. All the experimental results indicated that this characteristic is chromosomal mediated and is different from the plasmid-mediated wild-type strains.

STRUCTURE AND SENSORY EVALUATION

Dietary fiber

A procedure for the analysis and chemical characterization of dietary fiber from Canadian vegetables has been developed. The procedure as applied to celery consisted of preparation of an 80% hot ethanol-insoluble residue (yield 1.59%) that was analyzed for moisture, ash, protein, starch, and uronic anhydride, which together accounted for 0.73%. The remainder (0.86%) is composed of 28.9% cellulose and 25.8% noncellulosic neutral polysaccharides. The sum of cellulose, noncellulosic polysaccharides, uronic anhydride, and lignin in celery added up to 81.3% of 1.59% corresponding to 1.29% dietary fiber. Work on the determination of the fiber content of parsnip, rutabaga, and squash is in progress.

Microstructure

Cold-stage scanning electron microscopy has been introduced as a modern technique used to examine foods in the frozen hydrated state. By modifying the procedures used in other scientific disciplines, experimental conditions were found for the prevention of artifacts in the micrographs of fungi grown in foods such as soft cheese and salami. The new technique made it possible to study the morphology of fungal hyphae in great detail. The findings are important for the taxonomy of fungi and other microorganisms.

Fixation of milk fat in dairy products developed earlier was used to study the dispersion of fat in various types of cream cheese and its relationship to spreadability.

Collaborative study of comminuted meat products with an industrial company revealed evidence of interactions between soluble meat and vegetable proteins (as part of the fillers used). Restricted gelatinization resulting from limited moisture availability was also observed.

Continuing collaborative study with an industrial company on the effect of the so-called hot melt on reworked process cheese has led to a hypothesis, supported by fluorescence microscopy, that fat interacts with protein on prolonged heating on a molecular basis. Meltability of this complex is severely reduced.

Encapsulation of semiliquid milk products in agar gel followed by freeze fracturing was developed in order to study the internal structure of particles (such as lactose crystals or aggregated thickening agents) causing grittiness in some products.

Microscopy

Fluorescence microscopy was used to investigate the effects of processing and cooking on the structural and microchemical composition of several rolled oat products. The inner endosperm of oats was more susceptible to processing than the aleurone and subaleurone layers as evidenced by the extent of cell wall breakage. Among the products examined, instant rolled oats showed more breakdown than old fashioned rolled oats. Furthermore, most starch grains in old fashioned and quick rolled oats retained their polygonal structure, unlike those in instant rolled oats, which contained partly swollen and folded structures. Cooking completely altered the native structure of starch. In addition, it induced the release of β-glucan from the inner endosperm cell walls. Most of the aleurone and subaleurone cell walls remained intact, with detectable β-glucan and phenolic compounds even after cooking still encompassing protein bodies with their phytin inclusions. Both protein and lipid bodies were structurally denatured by processing and cooking. Despite altered structures, they remained detectable by standard techniques, indicating that chemical changes and material loss were minimal.

Sensory

The Sensory Evaluation Unit collaborated with Agriculture Canada scientists (Animal Research Centre, Brandon Research Centre, and Food Production and Inspection Branch).

Hull-less oats, developed by the Ottawa Research Station, included in the diet of laying hens caused a change in the color of egg yolks. The intensity of the egg yolk color was inversely related to the level of oats in the diet.

Continuing studies on the effects of line, breed, and sex on the eating quality of pork confirmed earlier observations, i.e., no differences were noted between control and select lines, gilts, and boars and the Yorkshire and Hampshire breeds.

The sensory quality of grades A and C1–C2 beef was compared. No perceivable quality differences were noted between A1 and C1 grade beef obtained from an eastern abattoir; results of comparative quality evaluation between A1 and C2 grade beef supplied by a western abattoir were inconclusive.

FOOD SAFETY AND NUTRITION

Nutritional value of potatoes

A new project has been established to update the data on vitamin C and mineral content of fresh and processed potatoes. In a preliminary survey of six varieties grown in Ontario, a large variation in the vitamin C content was noted, which was independent of growing location. The newer varieties Shepody (21 mg/100 g) and Yukon Gold (17 mg/100 g) were higher in vitamin C than others, including Russett Burbank (11 mg/100 g). Partly fried frozen French fries prepared from the same varieties showed little apparent loss of vitamin C. The iron content was not affected by variety (approximately 5.5 ppm fresh weight), but some evidence of variation according to growing location was noted.

During 1986 a much larger survey was conducted with samples of Russett Burbank, Kennebec, Superior, Shepody, Red Pontiac, Norchip, and Yukon Gold obtained, where possible, from multiple locations in provincial growing trials. Vitamin C, Fe, K, Mg, Cu, Zn and moisture are being determined. French fries from frozen- and fast-food outlets have been sampled from local stores, and preliminary results show a large seasonal vitamin C variation. Work on sampling and preparation techniques was also undertaken. There seems to be no evidence to support the notion that potato skins contain more vitamin C than the flesh; in fact quite the opposite appears to be true.

Safety of fermented dry sausage

Cured uncooked or raw-ripened dry and semidry sausages are delicatessen specialties or gourmet items that are estimated to represent about 6% of the commercial trade in meat products. The manufacture of these sausages requires the use of raw materials of high microbiological quality. Consequently, producers are seeking alternative ingredients that will lead to cost reduction. A series of experiments were undertaken to determine whether it was safe and practical to extend pork and beef with mechanically separated chicken meat (MSCM) in the formulation of sausages that would be consumed without cooking.

Raw-ripened, dry, fermented sausages formulated with 10 or 15% MSCM were contaminated with *Staphylococcus aureus* (10^4 cells per gram of meat) and *Salmonella typhimurium* (5×10^3 cells per gram). Bacterial starter cultures that were mixtures of either lactobacilli plus micrococci or pediococci plus micrococci as well as a third group of sausages acidulated with glucono delta lactose were used under commercial manufacturing conditions. Sausages were ripened at $\leq$22°C for 29 days. Changes in bacterial genera, pH, water activity, protein, fat, moisture, nitrite, nitrate, and sugar content were followed. Under the conditions of manufacture used, temperature ($\leq$22°C) proved to be most important in the control of added *S. aureus*, whereas rapid initial acidulation was found to be the main factor that controlled proliferation of added *S. typhimurium* and naturally occurring *Salmonella*. Results also showed that MSCM could be safely incorporated up to 15% (w/v) in fermented sausages without substantial effect on pH, water activity, and other chemical indices of quality. Sausages formulated with 15% MSCM tended to be the least tough in sensory tests but had a drier and harder outer edge.

Survival and growth of *Yersinia enterocolitica* in egg washwater

Yersinia enterocolitica, a potential human pathogen, has been isolated from a variety of foods including milk, vegetables, beef, lamb, pork, and poultry. Some isolates from poultry have been found to be clinically important serotypes. Surveys in several countries have shown that *Y. enterocolitica* was present in 25–68% of poultry and processed poultry products. These findings indicated a need to examine the potential for survival of *Y. enterocolitica* during the washing, grading, and commercial packaging of eggs. In the work undertaken, *Y. enterocolitica* serotypes 0:3 and 0:8 (biotypes 4 and 2, respectively) were examined for their ability to survive in a 1% (w/v) whole-egg suspension adjusted to a range of pH values (7–10.5) with detergent while being held at temperatures (38 and 42°C) often encountered in washwater at commercial grading stations. Since *Y. enterocolitica* is a psychrotroph, the potential for its growth during transport of samples from grading stations to the laboratory was also checked in samples held over a range of temperatures (6, 10, 12, and 15°C). *Yersinia enterocolitica* (0:3) was able to grow in the synthetic egg washwater at pH 10 and 38°C (conditions frequently found at grading stations). Both *Yersinia* strains were able to grow at refrigerator temperature when the pH was ≤10. It was concluded that the cleanliness of egg-grading stations and maintenance of an antibacterial condition in washwater (temperature ≤40°C and pH ≤10) play an important role in preventing *Y. enterocolitica* from contaminating marketable eggs.

Dietary proteins

An analytical high-performance liquid chromatography (HPLC) method for determination of D-amino acids in dietary proteins was established. Formation of D-amino acids may occur during certain treatment of dietary proteins and cause decrease of their nutritive value. Application of this method to oat proteins revealed very low levels of D-amino acids.

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INTRODUCTION

This report summarizes highlights of research carried out during 1986 at the London Research Centre in support of departmental objectives in environmental quality and crop protection. The centre was established in 1951 to investigate the problems created by the introduction of synthetic organic pesticides. Present research programs reflect the current health and environmental concerns regarding the agricultural use of pesticides by concentrating research efforts in integrated pest management (IPM) and environmental toxicology.

The IPM objective comprises four research activities. The pest management activity is aimed at developing IPM procedures, including biological control, for agriculturally and economically important insect pests. Research on stored products is directed toward the investigation of environmental and insect resistance problems and the development of more efficient fumigation procedures leading to a minimum of pesticide residues. The third activity concerns research on alternative pest control strategies. Studies on insects are aimed at identifying specific areas for attack so that pest control in the future will not rely upon the use of broad-spectrum toxicants. Research on natural plant defense mechanisms in disease-resistant and susceptible agriculturally important crops has the objective of using natural defense mechanisms by biotechnology, chemical manipulation, or the breeding of resistant varieties. The last activity under the IPM objective concerns research on systemic fungicides. Studies are carried out on the efficacy of systemic fungicides and on the plant pathological, biochemical, biophysical, and structural parameters of fungicide activity and resistance.

Research on environmental toxicology has three areas of activity. The first deals with the effect of pesticides on nontarget soil invertebrates and agriculturally important soil microorganisms. The second is concerned with the determination of the behavior, persistence, and environmental fate of pesticides and their movement through the environment. The third is concerned with establishing the mode of action of growth regulators and toxicants by carrying out studies on insects and plants related to vital processes of growth and development.

This report records only the highlights of our accomplishments for 1986; more detailed information can be obtained from the publication titles listed at the end of this report. Copies of the report, reprints of publications, and further information are available on request from the Research Centre, Agriculture Canada, University Sub Post Office, London, Ont., N6A 5B7; Tel. (519)679-4452.

H. V. Morley
Director

INTEGRATED PEST MANAGEMENT

Biological control of the onion maggot

Further progress was made on the feasibility studies aimed at incorporating biological control using parasites and predators in an integrated pest management program.

The feasibility of using the fungus *Entomophthora muscae* (EM) as a biological control agent for onion maggots and house flies received further consideration. The in vivo culture method has been simplified, enabling, with minimum difficulty, the production of infected house fly and onion maggot adults. Cross-infectivity and virulence of the strains have been maintained with both host flies. An insect tissue culture medium was employed for in vitro culturing to overcome the problem of EM losing its vigor and infectivity to flies and becoming purely vegetative. Attempts were made to cultivate this culture on numerous different media to determine its growth and formation of conidia or resting spores. Two media were developed that gave good growth. To help in identification of EM species, a nuclear staining technique was used. The numbers and dimensions of conidia and nuclei showed species-complex to be present, which can be divided into three groups: London, Thedford–New York, and California, based on the cultures grown from flies from these four geographical areas. The nuclear number ranged from 4 to 12 in each conidium. Generally, as nuclear number increases, nuclear size decreases.

Research also continued on potential insect biological control agents. Despite published work to the contrary, it has been established in the laboratory that the widely spread *L. terrestris* earthworms are a perfectly suitable larval food form for the onion fly predator, *Coenosia tigrina* (CT). Moisture rather than the presence of a larval host appeared to be the major oviposition stimulus for female CT. Although CT pupae did not survive at –3°C, properly conditioned larvae survived for at least 3 weeks, indicating that larvae of CT can overwinter.

Other studies on the onion maggot predator, *Aleochara bilineata* (AB), showed that although host onion maggot (OM) pupae could survive at –3°C for at least 6 months, survival of AB larvae within the OM host began to decline after 3 months at that temperature. Adult AB could be stored 4–5 weeks at 5°C with no decrease in fecundity and longevity. Stockpiling of adult AB for mass release was thus shown to be feasible. Statistical analysis of AB dispersal patterns was recently completed by the Statistical Research Service and demonstrated that AB dispersal is probably random, since over several days wind and sun direction had little effect on distribution. This work demonstrated that current experiments on inundative releases of AB are using acceptable dispersal techniques.

Work began on a new predator, *Scatophage stercoraria* (SS), which was introduced from the field. Rapid progress was made in adapting this OM predator to laboratory rearing conditions. The wider distribution of SS, its ease of rearing, and its voraciousness make this insect a good prospect for biological control of the OM.

Monitoring

The yellow pan traps baited with allylisothiocyanate again proved to be very successful for rutabaga pests and also provided a good measure of the presence of flea beetles and aphids. The method has been adopted by the turnip mosaic virus task force. For the third successive year turnip mosaic virus (TUMV) was a problem in rutabagas. Winter rapeseed and canola are excellent hosts for the cabbage maggot (CM) and will provide additional CM pressure on rutabagas if rapeseed crop areas increase.

Flight interception traps were effective monitors for onion maggot, seedcorn maggot, and the onion maggot predators *C. tigrina* and *S. stercoraria*. A plate trap, modified from a Quebec model, was tested for the first time and collected greater numbers of carrot weevils than did standard carrot discs.

Enhanced microbial degradation

Previous work has shown that under certain conditions microbial populations in soils rapidly acquire the ability to degrade many carbamate and organophosphorus pesticides. This enhanced microbial degradation results in erratic pest control and may in fact be erroneously attributed to resistance.

The role of accessibility of an insecticide to microbes in evaluating the importance of adapted soil microbial populations was demonstrated by the difference in behavior observed between granular formulations and the analytical forms of carbofuran, fensulfothion, isofenphos, and trimethacarb in natural and microbially activated clay loam soils. Accessibility, as assessed by the persistence of the granular formulations in active soils, increased with increasing soil moisture in the case of carbofuran, fensulfothion, and trimethacarb but was little affected for isofenphos. This interaction between the accessibility of formulated materials and the soil moisture appears to be an important factor in understanding the behavior of insecticides in the field.

Soil microbial populations adapted to degrade disulfoton sulfoxide + sulfone, or phorate sulfoxide + sulfone were effective in degrading terbufos sulfoxide. Apparently, the microbes degrade these dialkyl sulfoxides equally readily. This is in contrast to the behavior of microbial populations adapted to degrade fensulfothion (an aryl alkyl sulfoxide), which showed no activity toward the sulfoxides of phorate, disulfoton, terbufos, or aldicarb in the one soil studied. Some structure-activity relationships are thus slowly emerging from this work.

A simple technique was developed using soil contained in petri dishes and a sampler consisting of a number of concentric metal rings. This was found to be an effective method of studying both the movement of insecticide away from a granule of formulated material and the size of the region in which enhanced microbial activity develops when the granule is placed in the soil. The method is easily adaptable to studying the movement of antiinsecticide activity from a region in which the soil is active to an initially active region. The technique provides another tool for use in attempting to understand the behavior of granular formulations in soil.

Solarization

A preliminary test of the efficacy of soil solarization was conducted at a site in a field where below average yields of potatoes have been historically obtained. Six replicated plots were covered with plastic or left uncovered. Assays were carried out for *V. dahlaiae* and for the populations of nematodes, (Vineland Research Station) soil microflora, and insects. In addition, soil samples were brought back to the laboratory and used as a medium for cultivation of plants not susceptible to *Verticillium* (soybeans and corn) and one very susceptible species (eggplant). *Verticillium* propagules were not detected in the top layers of four of the solarized soils and were at low levels in the other, whereas in the uncovered sites the inoculum density of this pathogen was high. Negligible reductions were observed in soils from lower depths. Soybean plants were found to develop identically in solarized and nonsolarized soils when grown under controlled environmental conditions. In contrast, corn plants grown in solarized soil showed a 20% increase in fresh weight and eggplants increased by 125%. A distinct change in fungal populations was discernible in solarized soils cultured on agar media.

STORED PRODUCTS

The fumigant phosphine has been found to have a slow, cumulative, toxic action in insects, even at low concentrations. Adults of the red flour beetle, *Tribolium castaneum* (Herbst), first exposed to a sublethal dose of phosphine (LD_{10}) were found to be highly susceptible to a second similar treatment. The mortality in insects increased to 82% when they were retreated with the fumigant within 24 h of the first application. However, insects regained their normal tolerance for phosphine when the interval between treatments was lengthened to 4 days, suggesting that recovery was related to repair of a lesion at the target site.

Uptake of fumigant was also greatest when the period between treatments was 24 h and when 98% of the absorbed fumigant was found to accumulate in the cytosolic fraction. A line of *T. castaneum* selected for resistance to phosphine acquired a four-fold increase in the LD_{50} in five generations, and these insects were found to take up less phosphine than the susceptible strain. Oxygen consumption by insects declined after treatment with phosphine, indicating some effect on respiratory metabolism. Treatments with hydrogen cyanide did not increase the susceptibility of insects to phosphine, suggesting no synergistic action.

Exposure of phosphine-treated insects to pure oxygen appreciably increased their mortality. These and other results obtained suggested that repeated treatment of the red flour beetle with a sublethal dose of phosphine caused prolonged inhibition of catalase, perhaps resulting in cytotoxic effects produced by an increase in reactive oxygen radicals.

Studies to characterize the major sites of methylation in grains and other food products that have been treated with methyl bromide were continued. Early investigations using ^{14}C-methyl bromide and corn showed that nearly half the fumigant that reacted with corn constituents was associated with the germ, the portion of the kernel which is high in protein. Isolation of protein from whole, ground corn indicated that a large fraction of the radioactivity was associated with the various classes of corn proteins. Further characterization, however, by hydrolysis was complicated by the labile nature of one or more of the radiolabeled products.

Attention was directed to the identification of radiolabeled volatile substances resulting from hot alkali-induced decomposition of constituents present in corn treated with methyl bromide. As expected, the major product containing approximately 25% of the radioactivity in the corn sample was dimethylsulfide originating from *S*-methylmethionine sulfonium bromide. Two other volatile substances, methanol and methyl mercaptan, having approximately 16% and 2.5% respectively of the radioactivity of the corn, were also identified. After neutralization, 39% of the radioactivity remained as nonvolatile residue.

Studies aimed at determining whether DNA of corn is methylated during fumigation were also initiated. Methods were developed using untreated corn for the isolation of the DNA fraction and high-performance liquid chromatography (HPLC) analysis of constituent purines and pyrimidines after formic acid hydrolysis. Studies to date from corn treated with methyl bromide indicate that 7-methyl guanine and 1-methyl adenine are the major methylated products arising from the DNA fraction.

Concerns by provincial health authorities have been expressed regarding levels of methyl bromide in the vicinity of fumigated flour mills. No data seemed to be available on which to decide whether this concern was justified or to establish whether proposed safety levels are practical.

In order to carry out this investigation, computerized gas chromatographic sampling equipment was designed and built, which enabled continuous analysis at selected time intervals and locations. This equipment was used to measure methyl bromide levels at three flour mills in Ontario in both spring and fall.

The levels of methyl bromide established in three flour mills during fumigation varied according to the size and condition of the structures and the weather conditions encountered on the days of the treatments. In a 15-h exposure the concentrations in the mills dropped by 75% or more, even when additional fumigant was added to supplement the dosage originally applied. During the aeration period, a maximum concentration of 27 ppm was recorded at a distance of 25 m from one mill in the first 5 min after the beginning of the aeration procedure, and at 20 min a concentration of 7 ppm was found.

With regard to the efficacy of the treatments for insect control, particularly under circumstances where rapid loss of fumigant early in the treatment led to low concentrations for much of the exposure period, the results gave some indication as to the significance of these low concentrations. From the data obtained in the laboratory, it was observed that continued exposure to a low concentration can increase efficacy when insects are first exposed to higher concentrations. The results indicated that continuing a treatment after the concentration falls to a low level, as it did in the field trials described here, can have some value. Some control can be achieved under these conditions even at low concentrations of methyl bromide, which are normally ineffective.

Although the experiments were carried out at only three flour mills, they do give some indication of the great variation that may take place in various facilities under various atmospheric conditions. Furthermore, they suggest that the appreciable loss of fumigant that occurred during the treatment could give rise to relatively high concentrations in the outside atmosphere during the treatment period.

Data from all treatments clearly show that the internal concentration at the end of the exposure period was a relatively small proportion of the initial dosage applied (calculated on the basis of weight of fumigant applied). Consequently, because a large proportion was lost through leakage and sorption during the treatment, any hazard posed by exhausting the residual gas at the end of the treatment was correspondingly reduced.

Studies on the mode of action of phosphine were continued. Hypophosphite, one of the oxyanion breakdown products of phosphine, was found to be responsible for the observed inhibition of the enzyme catalase in vitro. Activity of catalase in the granary weevil, *Sitophilus granarius*, exposed to LD$_{50}$ levels of phosphine was not significantly different from the controls, and resistant insects had less catalase than susceptible ones. Consequently, attention was shifted back to the enzyme cytochrome oxidase, which was known to be noncompetitively inhibited by phosphine.

ALTERNATIVE PEST CONTROL STRATEGIES

Plant diseases

Research in this area is directed toward obtaining an appreciation of the basic processes involved in plant–pathogen interactions in resistant and susceptible crops. The potential benefits of these studies would be the ability to activate the plants' natural defense mechanisms and to provide a firm basis for breeding for genetic resistance.

In collaborative work with workers at the University of Western Ontario, the selective activation of host genes for glyceollin biosynthetic enzymes in resistant responses of soybeans has been demonstrated. It has been shown that at least two genes, which transcribe the mRNAs for the synthesis of two key enzymes in glyceollin biosynthesis, are activated specifically in the resistant response within 3 h of inoculation but not in the susceptible response. The enzymes are phenylalanine ammonia lyase, which directs phenylalanine into pathways of phenolic metabolism, and chalcone synthase, which catalyses the first committed step of flavanoid biosynthesis. It is possible that these two enzymes provide control points in glyceollin biosynthesis. Activation presumably results from specific messages reaching the nucleus in the resistant response either directly from the pathogen or indirectly because of lifting of feed-back controls. The work provides a basis for future investigation of mechanism of gene activation, leading to an understanding of how glyceollin biosynthesis is turned on in contact with the pathogen, hopefully indicating possible procedures for artificial manipulation of the process.

P. syringae pv. *tomato*, the causal agent for bacterial speck of tomatoes, responds to changes in its chemical environment by altering its pattern of motility. This process, called chemotaxis, could play an important role in the establishment of infection sites on the plant surface. An efficient assay system for studying this phenomenon was developed and is being used to examine the response of the pathogen to various organic components of the fruit.

Fructose and glucose, which represent 50% of the dry matter of fresh tissue, are very weak attractants when compared with malate and citrate, the fruit's major organic acids. Malate, the strongest attractant tested, is the predominant organic acid in small, immature green tomatoes. Tomatoes at this stage of development are also the most susceptible to bacterial infection. Every amino acid tested attracted *P. syringae* pv. *tomato*, but the two that elicited the strongest response, serine and proline, were present in relatively low levels in the fruit.

Using Tn5 mutagenesis, three virulence and nine pathogenicity mutants of *P. syringae* pv. *tomato* were isolated. Although these mutants exhibited varied patterns of growth on tomato plants, none grew as well as the wild type. The three virulence mutants appeared unable to produce the chlorosis-inducing toxin coronatine. Five of the pathogenicity mutants were unable to induce a hypersensitivity reaction on tobacco plants. Parent-strain DNA flanking the Tn5 insertion from one of the pathogenicity mutants has been cloned and used to locate homologous DNA on the pathogenic parent strain genome. This homologous parent strain DNA has been isolated and cloned into cosmid vector pLAFR3.

The secondary metabolite produced by *P. fluorescens* Pf5, which has biological activity against the bacterial speck pathogen, was identified as the siderophore pyochelin. It was isolated as a previously unknown complex of two pyochelin molecules with two zinc atoms. Although the complex is an artifact of isolation, it is of considerable interest for the following reasons: it serves as an excellent vehicle for the isolation and purification of pyochelin; its properties will throw light on those of the much less easily studied but important iron complexes of pyochelin and other siderophores; and it may have practical application for the scavenging of zinc and other divalent metals from natural microenvironments.

Cercospora traversiana was found to produce neither of the two common *Cercospora* toxins (cercosporin and dothistromin) but did produce appreciable amounts of a previously unknown compound shown to be a unique diterpenoid with the carbon skeleton of a fusicoccane but the functionalities of the tricyclic portion of the sesquiterpenoid ophiobolanes. Both these groups of fungal metabolites have received much attention as phytotoxins, and the *C. traversiana* compound therefore clearly warrants thorough study of its biological activity and significance as well as biosynthetic origin.

The bacterial rot pathogen *Pseudomonas viridiflava* was found to possess both constitutive and inducible transport systems for choline and certain natural choline derivatives; this system appears to be an essential component of the pathogenic mechanism, since choline was found to be released from plant phospholipids during attack by the bacterium, and as a nutrient choline would be a source of both nitrogen and carbon. Transport systems for these compounds having comparably high activity have not previously been reported in bacteria.

Insect pests

Research in this area is directed toward gaining an understanding of basic life processes peculiar to the insect so that methods of selective, specific control can be developed that do not rely upon broad-spectrum toxicants.

Both enzymes associated with the insect molt, namely chitinase and chitin synthase, work on an insoluble substrate deposited outside the cell membrane. Their spatial association with substrate would by definition be a significant property related to control of their activity. A better understanding of this physiological unit (i.e., insoluble substrate–enzyme complex) would give us a better tool with which we can try to interfere with the activity of these enzymes in the search for selective control. Thus the enzymes are probably associated with the cell membrane and should be separable from the rest of the cell contents through centrifugal fractionation. Unfortunately, when such separation was attempted with the chitin enzymes, all activity was lost. In an attempt to obtain some general understanding of the principles involved in particulate substrate–enzyme complexes another system was examined as a model, namely the cell glycogen particle that was associated with it, the enzymes responsible for its biosynthesis and breakdown. Preliminary work with this system was carried out to see if fractionation can be the result of the properties of the proteins associated with the particle rather than the properties of the polymer that makes up the particle. The results so far are encouraging. The importance of this work lies in its relationship to the insect molt, which is considered to be a likely target site for future pest-control measures.

Further evidence of the complexity of the mixture of myoactive peptides in the cockroach *Periplaneta americana* was obtained. Both heads and bodies appear to contain at least two major substances (neutrolins) capable of inhibiting contractions elicited by proctolin.

ENVIRONMENTAL TOXICOLOGY

Work directed toward determining the movement and persistence of pesticides in the environment was continued.

A 2-year field-testing of the effluent-collecting leaching apparatus was completed. A simulated 50-mm rainfall on the day following metolachlor (Dual®EC) application resulted in a marked transport down the Plainfield sand core, as well as traces in the effluent for a few days. There was no further movement throughout the remainder of the season, despite a heavy watering schedule. The kinetic half-life of metolachlor was 3–4 weeks. Aldicarb quickly converted (3–5 days) to its sulfoxide and subsequently to its sulfone in Plainfield sand cores and, as in past years, exhibited a moderately high degree of mobility. Under natural rainfall conditions, aldicarb was completely converted to its metabolites before it reached the bottom of the 70-cm soil cores (only 9% of applied material leached through the core as metabolites). Under the heavy supplementary watering schedule, 64% of applied aldicarb was recovered in the effluent (as its two metabolites). Current results indicate that this leaching technique does produce mobility and persistence data comparable with field plot data. It avoids a major problem inherent with field plot studies of obtaining sufficiently deep soil cores throughout the monitoring season to ensure that the leaching chemical is always within the sampling zone.

Pesticide toxicity and mode of action

New leads were obtained into explaining the problem of insect resistance. Studies on the interaction between certain organochlorine insecticides and model phospholipid membranes and biomembranes have shown the following: the insecticides partition more readily into model membranes that are fluid rather than rigid; the insecticides partition primarily into the lipid phase of certain biomembranes – no interaction was detected between the protein moiety of the membrane and DDT, and a comparison of the physical state of the lipid phase of various membranes from mammals and insects shows that insect membranes are generally more highly fluid, suggesting a possible clue for the greater susceptibility of insects to DDT. The only exception is that of the order Hemiptera, whose membranes are highly rigid and whose order also shows natural resistance to this insecticide.

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Research Station, Delhi, Ontario

PROFESSIONAL STAFF

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E.G. Ashby	Administrative Officer
P.E. Mills,[1] B.S.S., B.Ed., M.L.S.	Librarian

Tobacco

H.H. Cheng, B.Sc., M.Sc., Ph.D.	Entomology
W.A. Court, B.Sc., M.Sc., Ph.D.	Chemistry
S.K. Gayed, B.Sc., M.Sc., Ph.D.	Plant pathology
R.S. Pandeya,[2] B.Sc., M.Sc., Ph.D.	Genetics and plant breeding
N. Rosa, B.Sc., M.Sc., Ph.D.	Plant physiology
B.F. Zilkey, B.S.A., M.Sc., Ph.D.	Plant physiology

New Crops

R.C. Roy, B.Sc.(Agr.), M.Sc.	Agronomy

Departures

E.K. Walker, B.S.A., M.S.A. Retired 29 January 1987	Plant science
Agricultural Energy Centre[4]	
M.J. Columbus, B.Sc.(Agr.) Seconded to transition crop team	Energy Specialist
Delhi Engineering Research Group[4]	
D.A. Stier, B.Sc. Program terminated 28 February 1986	Engineer

EXTENSION SERVICES[3]

N.W. Sheidow, B.Sc.	Tobacco
M.C. Watson, B.S.A.	Tobacco

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[1] Seconded from Libraries Division, Corporate Management Branch.

[2] On work transfer to Plant Research Centre.

[3] Provided by Ontario Ministry of Agriculture and Food.

[4] Provided by the Ontario Flue-Cured Tobacco Growers' Marketing Board and the Canadian Tobacco Manufacturers' Council.

INTRODUCTION

The Delhi Research Station conducts a multidisciplinary research program in support of the flue-cured tobacco industry in Ontario, Quebec, and the Atlantic region. The program includes research in plant science, soil science, crop protection, genetics, chemistry, biochemistry, and physiology in support of mission-oriented research. A program on new crops is currently focusing on alternative or rotational crops for the sandy soils of the tobacco area.

Reprints of research publications and copies of this report are available from the Research Station, Research Branch, Agriculture Canada, P.O. Box 186, Delhi, Ont. N4B 2W9; Tel. (519) 582-1950.

P. W. Johnson
Director

TOBACCO PRODUCTION

Seedling production

Seedling production in unheated greenhouses is often subject to low-temperature damage, primarily during the first 3 weeks of the greenhouse season. Plastic covers provided 3–5°C of protection from freezing or chilling injury. Black plastic covers are preferred in order to avoid the higher temperature increases that occur under clear plastic covers, particularly if removal is delayed on sunny days.

Fertilization

Increased nitrogen fertility had a positive effect on axillary bud growth (suckers). As applied nitrogen increased from 28 to 38 and 48 kg/ha, yield and crop returns increased significantly, grade index tended to increase, and the incidence of weather fleck decreased significantly. Added nitrogen fertilization reduced maturity for all varieties.

Cost of production

Thirty-nine tobacco growers in the area participated in two economic studies completed in 1986. The first study investigated the cost of producing seedlings in muck seedbeds or in plug trays and transplanting. Seedlings grown in muck seedbeds cost $15.86 per 1000, including pulling costs, compared with $22.07 per 1000 for seedlings grown in 200-cell plug trays. Transplanting, replanting, and clean-up cost $29.60 per 1000 for bare-root plants versus $26.72 per 1000 for plug plants, resulting in total cost of $45.46 per 1000 for the seedbed system compared with $48.79 per 1000 for the plug tray system.

The second economic study investigated the cost of harvesting, curing, and stripping by three different farming methods. Labor was found to be the most significant single input cost, averaging 52% of the total cost. Farms that primed by hand and cured on lath averaged $1.36/kg, farms that hand-primed and cured in racks averaged $1.31/kg, and farms that machine primed and cured in bulk bins averaged $1.52/kg.

GENETICS AND PLANT BREEDING

New flue-cured tobacco cultivar released

In 1986, Delliot was licensed for commercial production in Canada. The original genetic code for this cultivar, 81SP10-BA, evolved from an interspecific hybridization study using *Nicotiana tabacum* L. and *Nicotiana rustica* L. Delliot's pedigree is [Delhi 34 <(NRT × Delhi 34) × Delhi 34>] × Virginia 115. Delliot is superior to Virginia 115 in yield, grade, and returns per hectare. Seedlings are light green, as are the seedlings of Delhi 34, with good vigor and early growth habits. Delliot is a tall cultivar with leaves spaced well apart on the stalk, giving the plant a cylindrical profile. Very few tillers are produced at the base of the main stem. It expresses a superior tolerance for black root rot compared with the check cultivars Virginia 115 and Delhi 76. Agronomic, chemical, and physical characteristics for Delliot are improved over Virginia 115. With a higher nicotine content, Delliot expressed a tar-to-nicotine ratio about 8% lower than that of Virginia 115, a significant achievement. In general, Delliot exhibited better color and visual ratings, with a higher percentage of orange grade color than that of Virginia 115 and Delhi 76. Higher nicotine and a lower tar-to-nicotine ratio of the cultivar Delliot further improve the quality of Canadian tobacco for domestic and export markets.

CHEMISTRY

On a survey of 29 farms, the total alkaloid content of the lower stalk position leaves of the 1986 crop were similar to both the 1985 values and the long-term averages; however, leaves from the upper stalk positions contained somewhat lower amounts of total alkaloids than in 1985 or the long-term average. Reducing sugars were higher in the leaves of all stalk positions than in 1985 or the long-term average. This resulted in a higher sugar-to-alkaloid ratio. Levels of total nitrogen and chlorine were generally lower than the 15-year average. Lamina weight values did not differ greatly from the long-term average but were considerably lower than those of the 1985 crop for all stalk positions.

An improved method was developed for the analysis of the major nonvolatile organic and fatty acids of flue-cured tobacco (*Nicotiana tabacum* L.). The tobacco acids were analyzed by capillary gas chromatography as their methyl esters on a fused silica capillary column bonded with a cyanopropylsiloxane stationary phase. Fructose, glucose, sucrose, and inositol as well as several tobacco acids including citric, malic, caffeic, and quinic acids could also be determined on an aqueous extract of tobacco. These were quantitated by capillary gas chromatography as their trimethylsilyl derivatives on a fused silica capillary column bonded with a dimethylpolysiloxane stationary phase. Oxalic, succinic, and malonic acids could not be determined by this procedure. The extraction of tobacco with water was found to remove only traces of fatty acids.

Characteristics of cigarettes and cigarette smoke were measured for flue-cured tobacco grown on 26 Ontario farms in 1985. Three varieties grown on the farms were tested – Delgold (69%), Candel (27%), and NC-89 (4%). Cigarette characteristics of weight, pressure drop, and puff number were very close to 1980 levels and were at the lower end of the range experienced since 1980. Total particulate matter (TPM) and tar levels were lower than the long-term average levels. Nicotine was slightly higher in 1985 compared with 1980 levels and higher than the long-term average. Mean total aldehydes were the lowest level in the past 5 years, and neophytadiene was similar to the 1984 level.

TOBACCO PROTECTION

Entomology

Insect control. Acephate transplant-water treatments over 4 years were consistent and effective in controlling several early-season insects, including cutworms, root maggots, wireworms, flea beetles, tobacco thrips, and aphids, for 2–4 weeks, depending on the species and the rate of application. These treatments had no adverse effects on yield or quality of flue-cured tobacco. High rates of acephate were phytotoxic to leaves, but no adverse effects on the plant growth were observed.

Efficacy data from 6 years of comparative tests have shown that rainfall after the spray deposit has dried does not reduce the toxicity or residual activity of acephate, cypermethrin, deltamethrin, and permethrin for cutworm control after transplanting. As a matter of fact, a rainfall after the soil treatment can improve the efficacy of chlorpyrifos, cypermethrin, deltamethrin, and permethrin in the soil in a dry spring.

Aphid survey. Infestations of the green peach aphid, *Myzus persicae* (Sulzer), were widespread and reached economic threshold levels between mid July and mid August in 1986. Over 80% of the tobacco crop area was treated with insecticides. A red biotype of the green peach aphid was recorded on flue-cured tobacco for the first time in Canada.

Plant pathology

In 1983 and 1984, Ridomil 240 EC was tested for its efficacy in protecting tobacco against blue mold. The systemic fungicide was applied in the planting water with active ingredient (a.i.) at rates ranging from 50 to 400 g/ha. Rates of 100 g and higher were phytotoxic and caused stunting of tobacco plants early in the season, but final yield and economic returns on the crop were not significantly affected. The 200-g rate did not affect the level of reducing sugars and total alkaloids nor adversely change the smoke quality of the leaf. The 400-g rate resulted in higher N in the cured leaf, probably a reflection of leaf immaturity. Residues of metalaxyl in the tobacco leaf at the rate of 200 g per application could be detected in the leaf during the 1983 growing season, but in 1984 residues in the leaf disappeared by 11 July. In both years, the leaf bioassay technique gave a reliable indication for blue mold susceptibility if tested before the leaf approached maturity. The results of this study suggest that Ridomil applied in the planting water at a rate of 200 g/ha is a more efficient substitute for the currently recommended preplant soil treatment.

Axillary bud control

Two applications of a contact fatty alcohol as an inhibitor for axillary bud development significantly reduced bud number and total weight but had no effect on leaf dimensions, grade index, and maturity. Yield was significantly increased primarily through the control of axillary bud growth. Of the five registered formulations evaluated, only one material consistently provided the best control, and variations in percentage of control for all materials varied from 70 to 92%. Sucker pressure was greater in 1986 than in 1985.

NEW CROPS

Twenty-five peanut lines were evaluated for licensing this year. Several had an arithmetic yield increase over OAC Garroy. Tobac Curing Systems, a local machinery manufacturer, has sold two two-row peanut harvesters to Florida growers, with potential sales in the future.

Thirty cultivars of winter canola were evaluated, and yield ranged from 2300 to 3700 kg/ha, with a mean of 3075 kg/ha. Five cultivars were supported for registration. A combination of 25 kg of fall-applied nitrogen plus 200 kg of spring-applied nitrogen produced the highest yields. Several postemergent herbicides provided good control of volunteer winter rye in winter canola.

Yields of both white and colored beans were good this year. Some damage by an early fall frost (7 September) was evident on the later maturing colored bean cultivars. Yield increases were noted, with nitrogen at up to 150 kg/ha; however, soil type, field history, and economics must be accounted for before increasing nitrogen rates above 60 kg/ha. An increase in white bean crop area on sands is expected in 1987 because of good yields last year, high returns, and an active recruiting program by a local bean dealer. The seed quality of white beans is going to be a problem because of wet fall weather in the traditional area for growing white beans.

Experiments with direct seeding evening-primrose show good promise; however, overwintering data must still be collected. Plot yields averaged 600 kg/ha, down from the previous year.

The commercial production of chick peas at six locations provided mixed results. Yields ranged from 0 to 700 kg/ha. A 2nd year of commercial production is being planned in order to sort out the previous problems. Pakasura Ltd. is still interested in obtaining a local supply of chick peas.

An increase of 750 and 1190 kg/ha was observed with one and two irrigations, respectively, of field corn. A population × hybrid interaction indicated a need to perfect each hybrid in order to maximize yields with irrigation.

Tomato seedlings grown in muck seedbeds were of equal or better quality and price compared with imports from Georgia. Clipping was the most effective means of controlling seedling height. Precision seed placement as opposed to random sowing of the seedbed allows seeding density to be increased without decreasing seedling quality.

INSECT PESTS

Weekly monitoring of the potato leafhopper, *Empoasca fabae* (Harris), on the peanut crop showed that it occurred in late June and reached economic threshold levels in the first week of July and again in the first week of August. Insecticide treatments for control were employed by all growers.

Field observations on evening-primrose in experimental plots over a 2-year period showed that *Mompha breivittella* (Clem.), an insect that attacks and eats the seedpods, is the most consistent and important pest and is numerous enough to warrant a critical investigation of its biology and control measures.

A field survey of insect pests of winter canola has shown that there are no economically important insect pests. No insecticidal application is needed, at present, for growing winter canola in the Delhi area.

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Research Station, Harrow, Ontario

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B.R. Buttery, B.Sc., Ph.D.	Soybean physiology
S.J. Park, B.S.A., M.S., Ph.D.	Field bean breeding
A.H. Teich, B.A., B.S.A., M.Sc., Ph.D.	Winter wheat breeding
T.W. Welacky, B.Sc., B.Sc.(Agr.)	Field crop agronomy

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S.E. Weaver,[6] B.A., Ph.D.	Weed ecology

Departures

V.A. Dirks, B.S.A., M.Sc., Ph.D. Retired 31 December 1986	Statistics
L.F. Gates, B.A., Ph.D. Retired 7 July 1986	Virology and vegetable diseases
R.J. McClanahan, B.A., M.Sc., Ph.D. Retired 19 September 1986	Greenhouse and field vegetable insects
D.T.W. Quiring, B.Sc., Ph.D. Resigned 30 June 1986	Field crop insects
B.C. Smith, B.A. Retired 18 April 1986	Field crop insects

EXTENSION SERVICES[7]

J.C. Fisher, B.S.A.	Greenhouse and fresh market vegetables
L.A. Huffman, B.Sc.(Agr.)	Fruit crops and asparagus

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[1] Seconded from Libraries Division, Corporate Management Branch.

[2] Returned from educational leave 8 September 1986.

[3] On educational leave, Michigan State University, September 1986–.

[4] On educational leave, Ohio State University, September 1986–.

[5] Seconded to Smithfield Experimental Farm, October 1986–.

[6] On postdoctoral transfer of work, Long Ashton Research Station, England, and Agricultural University, Wageningen, the Netherlands, 8 September 1986 to 30 June 1987.

[7] Provided by Ontario Ministry of Agriculture and Food.

INTRODUCTION

The Research Station at Harrow serves southwestern Ontario, where favorable soils and climatic conditions permit an intensive and diversified agriculture. The station has 30 researchers conducting interdisciplinary research in commodity-oriented programs designed to improve yield, quality, and efficiency of crop production. Crops under study include field and greenhouse vegetables, stone fruits, pome fruits, corn, soybeans, field beans, and winter wheat. Crop improvements are achieved by the breeding of new varieties with superior characteristics and by the development of improved crop, pest, and soil management practices.

The report provides brief summaries of results obtained in 1986. Further information can be obtained by writing to the Research Station, Agriculture Canada, Harrow, Ont. N0R 1G0; Tel. (519)738-2251.

C. F. Marks
Director

FIELD CROPS

Corn

Atrazine metabolism in quackgrass. Root uptake studies showed that atrazine was readily translocated to the leaves of quackgrass, where it inhibited photosynthesis. Atrazine was metabolized to a less phytotoxic metabolite, desethyl atrazine, with subsequent metabolism to nonphytotoxic products. A constant source of atrazine in the soil either as residue from a fall application or early spring application will ensure that no new carbohydrates are being assimilated by the emerging leaves, forcing the plant to utilize its stored carbohydrates to produce new growth. Over time, root reserves are sufficiently depleted and the plant dies. During carbohydrate depletion the competitive advantage of quackgrass is reduced so that corn growth can be maintained.

Comparison of blade cultivator, ridge, and moldboard plow tillage. A 3-year study was conducted to evaluate the potential of blade cultivator and ridge-reduced tillage systems to improve the productivity of a poorly drained soil relative to a fall moldboard plow tillage system in a corn–soybean rotation. The results showed that spring soil moisture tended to increase as tillage was reduced, soil structure improved as tillage was reduced, emergence was generally unaffected by tillage, and early plant development and yield increase with tillage. Excess soil moisture appears to be the major limitation on this soil. Tillage systems that increase drying and internal drainage are the most productive.

Corn root distribution in relation to long-term rotations. The distribution of corn (*Zea mays* L.) root was observed in monoculture and in corn–legume rotation plots established in 1956 on Brookston clay loam soil. The results support the hypothesis that a more extensive corn root distribution is promoted by a corn–legume rotation. There was no indication of a root-restricting zone in either rotation.

Improved data collection program for a notebook-size computer. The use of notebook-size microcomputers for field and laboratory entry of data in agronomy and soils research is limited by the availability of data collection and formatting programs. Data collection programs were written in BASIC for the Epson HX-20 and PX-8 notebook-size microcomputers. The programs accept treatment identifiers and response variables for most experimental designs used in agronomic research and provide column- and line-formatted data output suitable for analysis without further editing. These data collection programs save time and improve accuracy when transferring data from field and laboratory observations to analysis programs that accept formatted ASCII input.

Tile drain discharge under various crops. Characteristics of tile drain discharge for a 14-year period were analyzed from 12 drainage research plots having fertilized and nonfertilized crops in a 4-year rotation of corn–oats–alfalfa–alfalfa, continuous bluegrass, and continuous corn on Brookston clay loam soil. The results indicate that fertilized crops contribute a greater volume of drain discharge to a stream than do unfertilized crops and that the major contribution occurred in March and April. Continuous corn and bluegrass contributed a larger drainage volume than rotation crops, and the effect of crop cover was related to the probability and amount of rainfall. This information will contribute to a better understanding of the relationship between cropping systems, drain discharge, and food volumes and peak flows of streams, which are important considerations in drainage design.

Tillage and herbicide residues in corn. The effect of ridge and no-till cultivation on atrazine and alachlor residues was determined in field corn production. Tillage had no effect on alachlor residues at the end of the cropping season. About 1% of the applied alachlor remained at harvest. Atrazine was more persistent, with 20% of that applied remaining in the soil at harvest. No accumulation of the predominant phytotoxic atrazine metabolite was evident. Atrazine residues were highest on the ridge-till treatments, probably because of dryer conditions on ridge tops. Residues on no-till and moldboard plowed treatments were below that which would be phytotoxic to subsequent crops, but residues on ridge-till treatments may reduce crop yield in triazine-sensitive crops following corn production.

Quackgrass control in corn and soybeans. Glyphosate applied at two-thirds the lowest recommended rate plus ammonium sulfate in the spring each year for 3 years achieved the same level of quackgrass control as a single application twice as high as the low rate. This annual application allowed for maximum crop yields with less herbicide cost. An additional application of atrazine for annual weed control in corn enhanced the quackgrass control at a more economical level than the use of sethoxydim for a similar purpose in soybeans. Thus a low-cost programmed approach to quackgrass control can be practical with either corn or soybeans.

Soybeans

Alternative host for soybean pathogen. Burley tobacco fields in southwestern Ontario were surveyed for propagules of *Thielaviopsis basicola*, incitant of black root rot of tobacco and of a large number of crop plants including soybean. The mean number of propagules per gram of soil was 42 (range, 0–726). Populations in field soils were directly related to the frequency of soybean and tobacco–soybean production in the same field. Greenhouse tests indicated that growth of susceptible cultivars of tobacco and soybean was reduced in populations of *T. basicola* found in field soil. Soybean–tobacco rotations should be avoided, and only those cultivars tolerant of black root rot should be planted.

Breeding. Average shoot growth of nine backcross-derived varieties carrying the *Rpsl-k* gene for *Phytophthora* resistance was 2.4 times greater than in the recurrent varieties that do not have *Rpsl-k* when grown in hydroponic culture with metribuzin added at 0.15 ppm. The greater metribuzin tolerance associated with the *Rpsl-k* gene may be the result of an uncharacterized allele at the closely linked *Hm–Hm* locus, which conditions metribuzin sensitivity.

Nitrogen fertilization. The response of the soybean cultivar Harcor and the white bean cultivar Harofleet to four nitrate levels (nitrogen at 0, 112, 224, 336 kg/ha) and two levels of phosphorus and potassium (with or without P at 60 kg and K at 112 kg) was studied in the presence of indigenous or added *Rhizobia* (strain US 110 for soybean, RCR 3644 for white bean). Subplots were fumigated with methyl bromide before planting. Nitrogen fertilization had no effect on soybean yield but increased yield of white bean, indicating that the nitrogen-fixing system in soybean is adequate for promoting maximum yield, but in white bean it is not. Fumigation increased yields in +PK plots and decreased yield in –PK plots. These effects were more marked in soybean than in white bean. A depression in yield associated with fumigation in –PK plots suggests destruction of mycorrhizal organisms that help in nutrient uptake. The beneficial effects of fumigation in +PK plots suggest that these (or other) microorganisms have a deleterious or parasitic effect when not needed for efficient uptake of soil nutrients.

Some effects of nitrate on soybean root development. The effect of nitrate on some morphological aspects of soybean (*Glycine max* (L.) Merr.) root growth and the role of drainage in the response were determined for two indeterminate soybean cultivars grown in mixtures of perlite and Brookston clay loam in the presence or absence of nitrate. Plants were grown in acrylic tubes in corresponding field and growth root experiments. Nitrate suppressed nodule development and increased top dry weight. Nitrate increased rooting density and root dry weight in the field test but decreased rooting density in the growth-room test. Top-to-root ratio was increased in the growth-room but not in the field test. Increasing the proportion of perlite to improve drainage generally increased rates of root extension, rooting density, and top dry weight in the field and in growth-room experiments. However, the soil mixture had no effect on nodule dry weight at either location or on dry weight of the root in the growth room.

Field beans

Breeding. Three cultivars of field bean, Aresteuben, Dresden, and Mitchell, with improved agronomic performance and disease resistance were released in 1986. Aresteuben was developed by backcrossing disease-resistant genes into Steuben yellow eye. It is resistant to the alpha, beta, gamma, delta, lambda, and epsilon races of bean anthracnose and to race 15 of bean common mosaic virus. Dresden is a bush, navy (pea) bean that has averaged 3 days earlier in maturity than Harofleet, a full-season cultivar, and 3 days later than Harokent, which has medium-early maturity. It has averaged about 2% lower yield than Harofleet and 9% more yield than Harokent and is resistant to all domestic races of bean anthracnose and to races 1 and 15 of bean common mosaic virus. Mitchell is an early bush navy bean with the same maturity as Seafarer and about 4% higher yield. It outyields OAC Seaforth by 8% and is one day earlier in maturity. The main advantage of the cultivar is its yield performance as an early-maturing cultivar. Foundation seed of the three new cultivars will be available to bean growers for planting in the spring of 1989.

Conventional and narrow (solid-seeded) row widths were studied in 2 tests with 2 short-bush cultivars and 14 upright breeding lines at 2 locations to determine yield performance of new archetype selections. The narrow-row width averaged about 15% more yield than the conventional-row width. There was no genotype by row-width interaction. Solid-seeded bean plants tended to grow slightly taller and bore bottom pods slightly higher above the ground level than conventional rows. The upright lines appeared to be a suitable type for solid-seeded beans, which have to be combined directly as opposed to the conventional method of harvest.

Wheat

Breeding. A line, H60-2, is partly resistant to scab and accumulates less of the mycotoxin deoxynivalenol than Harus. It has received 2 years of cooperative testing, and under conditions favorable to scab its yield in southwestern Ontario exceeds that of all recommended cultivars. Its anticipated release in 1988 is expected to provide greater protection against the ravages of scab than is provided by current cultivars.

Control of Fusarium scab. It has been demonstrated that partial control of scab (*Fusarium graminearum*) was possible through the use of cultivars with moderate resistance, such as Fredrick and Harus, which in epiphytotics had lower scab incidences than other cultivars with both high- or low-nitrogen fertilizer and accumulated less of the mycotoxin deoxynivalenol. Conversely, Augusta, the most susceptible cultivar recommended, was especially susceptible at high levels of nitrogen fertilizer applied in the spring. The expected shift in use of cultivars from Augusta to Harus should result in less scab and deoxynivalenol.

Nitrogen fertilization. Adjustment of levels of nitrogen fertilizer applied as spring top-dressing has been made possible as a result of a cooperative study in field plots across Ontario. Yield response of cultivars to levels of nitrogen were not significant but showed considerable differences in the response to other traits, e.g., grain protein of Fredrick and lodging of Houser were especially sensitive. Wheat producers can use this information in choosing levels of nitrogen for optimum economic yield, to regulate grain protein content, or to partly control lodging, leaf rust, and scab.

HORTICULTURAL CROPS

FIELD VEGETABLES

Cruciferous crops

Pest management. Monitoring techniques for integrated management of insect pests of cruciferous crops were evaluated in plots and in growers' fields. Action thresholds of 0.5 and 0.25 cabbage looper larvae (or equivalent) per plant early and late in the season, respectively, were found to be acceptable for protection of late-season cabbage by cooperating growers, indicating credibility of these thresholds in management of pests of this crop.

Green peas

Control of root rot. Discontinuing use of phenoxy herbicides and adapting interseason green-manure cropping should significantly reduce the severity of pea root rot. It was found that phenoxy herbicides such as MCPA and MCPB significantly increased the severity of root rot, particularly at high field temperatures (24–28°C). Other herbicides such as pendimethalin, trifluralin, and oryzalin had less adverse effect on peas than did phenoxy herbicides. Interseason green-manure crops such as oats, sudan grass, sorghum, and corn not only reduced the severity of root rot but also increased soil organic matter (average, 0.33% per year), which resulted in a substantial increase in pea yield.

Tomatoes

Breeding. Emphasis is being placed on germ plasm development in processing tomatoes and on utilizing related wild species and unadapted breeding lines to improve disease and insect resistance, stress tolerance, yield, and quality. Increasing the level of soluble and natural solids in tomatoes is a major objective of the processing tomato breeding program. A study was conducted to determine the following: the correlation between solids levels in selected F_2 plants and their F_3 lines; and the feasibility of using single-seed descent in the development of high-solids lines. A highly significant correlation (0.31) was found between the levels of solids of the 75 F_2 plants and the F_3 lines. When crosses were analyzed individually, however, only two of five crosses showed a significant correlation (0.65 and 0.76). In one cross, the correlation was only 0.03. When analyzed by type, a significant correlation was found between the F_2 plants and the F_3 lines only among the randomly selected plants. Among the plants selected for high Brix readings, where the F_2 range was smallest, there was no significant correlation ($r = 0.14$) with the F_3 lines. A population advanced by single-seed descent to the F_5 showed a significant correlation ($r = 0.65$) between the F_2 plants and F_3 lines, but the correlation ($r = 0.05$) between the F_2 plant and the mean of the F_5 lines was not significant.

Lycopersicon peruvianum is a wild relative of tomato in which several desirable traits have been identified. The barriers to sexual hybridization between these species, however, have prevented widespread use of this valuable germ plasm in tomato-breeding programs. Six treatments for overcoming this barrier to hybridization were evaluated, including embryo culture, embryo callus culture, ovule culture, use of immuno-suppressants, use of high-crossability peruvianum lines, and hormonal treatment of flowers and developing fruit. Only two treatments resulted in viable F_1 plants. Treatment of the flower with 225 ppm of GA_3 at 3 days postpollination resulted in one successful cross with LA 2330, from which a few viable F_2 seeds have been obtained. Attempts to backcross this material to tomato were unsuccessful. Culturing of the immature ovule 5 weeks postpollination resulted in 10 F_1 hybrid plants, all with PI 128648-6. In all, over 2000 ovules were cultured. A few F_2 seeds have been obtained from the ovule-culture-derived plants through embryo rescue techniques.

Two of eight media evaluated for enhancement of somaconal variation in tomato gave a high frequency of shoot regeneration from calli with several adapted cultivars. More than 100 plants have been regenerated from cultured leaf or cotyledon tissue from a range of tomato lines, including adapted cultivars and breeding material. Three plants were tetraploids, and several others were morphologically different from their source population. R-1 seed has been obtained from these plants, and the derived lines will be evaluated in the field to determine extent of variability.

Drip and sprinkle irrigation versus the productivity of field tomatoes. Four tomato cultivars (FM-6203, H-722, Ohio-7814, and Purdue-812) were grown on Fox loamy sand in 1986 to study the effect of drip and sprinkle irrigation on the tomato production for processing. The total rainfall from May to August during the 1986 growing season was 130 mm above the long-term average (282 mm). Rainfall in May was close to normal, and twice the normal amount of rainfall occurred in June. July rainfall was close to normal, and August was 29 mm above. Drip and sprinkle irrigation water was applied between July and the first week of August. Average marketable production for all cultivars with drip irrigation was 70.2 t/ha, outyielding nonirrigation by 21.2%; sprinkle irrigation outyielded nonirrigation by 11.7%.

Maximum density of growing tomato seedlings in multicelled trays with optimum field performance. Seedling cells were constructed from polyethylene tubing whose inner diameter ranged from 1 to 2.5 cm. Cell volume was altered by varying the length of the sections of polyethylene tubing. Various densities per square metre of greenhouse were obtained by supporting the tube sections in holes made in styrofoam sheets. Five separate seedling production trials and three outdoor plantings confirmed that the maximum density for greenhouse production seedling with optimum performance in the field was 4000 seedlings per square metre, with a seedling cell volume of 7 cm^3. The performance of these transplants and survival in fields susceptible to sandblasting were equal to or better than the best southern transplants.

Nightshade control in tomatoes. Nightshade control in transplanted tomatoes was obtained with either a preemergence- or preplant-incorporated application of metolachlor at rates ranging from 1.92 to 2.64 kg/ha. One trial in each of three growers' fields and three at the research station using five different tomato varieties indicated no crop phytotoxicity and over 90% control of the weed. Subsequent analysis of fruit samples, both processed and fresh, showed no evidence of residue. The above information indicates that this herbicide can be registered for use in tomatoes.

Sandblasting and its control. Field seeding of tomatoes on sandy soils is often unsuccessful because of sandblasting damage. Injury from sandblasting on such soils can be reduced if the seedlings are protected by rows of grain plants established on both sides of the tomato row and left in place for about 6 weeks. Experiments on the ability of plug transplants of various ages (rather than direct-seeded crops) to withstand sandblasting showed that very small tomato seedlings younger than 5 weeks of age are too tender and are severely damaged by sandblasting.

Sunscalding of tomato fruits reduced seed vigor. Excessive exposure of tomato fruit to the sun results in scalding of the fruit and either yellowing or even bleaching of the fruit wall. Normal fruit development is inhibited, and many of the seeds under the scalded portion develop poorly or not at all. Furthermore, seed vigor in sun-exposed fruit is greatly reduced, compared with normal fruit. Sixty to eighty percent of seed samples from fruit developing in the shade had high vigor. The seeds from sun-exposed or sun-scalded fruit in some cases was close to 100% germination, but the seed vigor, i.e., rate of growth during germination, was very poor. It is suspected that the high temperatures experienced in the sun-scalded fruits inhibit normal fruit and seed development.

Weed competition in relation to water stress and shading. The critical period of weed interference in field-seeded tomatoes was determined in 1981, 1982, and 1983. Weeds that were removed within 5–6 weeks after sowing or weeds allowed to develop 7–9 weeks after sowing did not affect tomato yields. The length of the critical weed-free period varied among years. A minimum of two weed control operations during the critical period were required to prevent yield losses. Reductions in tomato yields were correlated with dry weight of weeds and could be attributed both to reductions in light levels from shading and to weed competition for water, which resulted in stomatal closure.

GREENHOUSE VEGETABLES

Cucumbers

Biological control of insect pests. Simultaneous applications of the entomogenous fungi *Verticillium lecanii* and *Aschersonia aleyrodis* to cucumber plants in the greenhouse indicated that *A. aleyrodis* infected and killed the greenhouse whitefly at a lower temperature and lower relative humidity than did *V. lecanii*, suggesting the greater compatibility of *A. aleyrodis* with crop management practices. Applications of either fungus reduced mortality in populations of the whitefly by the parasite *Encarsia formosa*, but suppression of the pest was enhanced by the combined effect of the biological agents. *Aphidoletes aphidimyza*, a midge that is predaceous on aphids on greenhouse crops, has been found to prey extensively on the greenhouse whitefly in addition to its preferred host. These studies demonstrate the potential of biological control agents for control of insect pests of greenhouse crops.

Powdery mildew. Powdery mildew, *Aphaerotheca fuliginea*, is controlled by 0.5 g/L microfine sulfur formulations, and registration was granted under the minor use program for

1.5 g/L. Sulfur is compatible with the biological pesticide *Ampelomyces quisqualis*. Further control of powdery mildew is provided by the intermittent water-fogging system used by many growers for cooling crops.

Growing media for greenhouse cucumbers. Canadian-made rock wool has been found to be as productive as rock wool imported from the United Kingdom and the Netherlands, and upright peat-bags made at Harrow were as productive as any type of rock wool in this study. No yield advantage was realized by increasing the thickness of the rock wool slab beyond the standard 7.5 cm. The study demonstrated that foreign technology on soilless media could be effectively adapted to Canadian conditions while using domestic resources.

Gummy stem blight. Didymella bryoniae, together with other water-dependent pathogens, such as *Botrytis cinerea*, *Sclerotinia sclerotiorum*, and *Pseudoperonospora cubensis*, can be controlled in greenhouses equipped with computerized environment control simply by preventing temperatures from falling to the dew point.

Tomatoes

Irrigation of greenhouse tomatoes grown in peat bags. The yields of three cultivars (CR-6, Dombito, and Caruso) when grown in soil (controls) or in Harrow peat bags and exposed to four irrigation frequencies (1, 4, 8, and 16 times per day) were compared over two spring and two fall seasons. All irrigation regimes applied to peat bags resulted in the same volume of water applied per plant per day. The early marketable yields (spring crops) and the final yields (fall crops) of all three cultivars were higher when they were cropped in peat bags than when cropped in soil, regardless of irrigation frequency. However, there was no difference between the final yields of spring crops grown in soil and in peat bags, and irrigation frequency had no effect on yield. These results confirm the previously reported findings that the Harrow peat-bag system is as productive as conventional soil but also suggest that this system does not necessitate the use of a high performance (high cost) irrigation system, thereby enhancing its economic feasibility.

Vitamin C in greenhouse tomatoes. A 2-year study with the objective of establishing the seasonal variation of vitamin C content of greenhouse tomatoes grown in Canada and that of field tomatoes imported from the United States provided data that challenged the longstanding theory that the vitamin C content of tomato fruit is related to the light conditions during the cropping season. Instead, it was found that air temperature had a greater influence than light on the vitamin C content of tomato fruit. Furthermore, it was demonstrated that greenhouse tomatoes produced in Canada had similar levels of vitamin C to field tomatoes imported from Florida.

TREE FRUITS

Apple

Fire blight. Apparently healthy apples of the cultivars Ida Red and Red Delicious collected from orchard trees with and without fire blight symptoms were analyzed for the presence of epiphytic and endophytic *Erwinia amylovora*. The organism was not detected on fruits of either cultivar from healthy and diseased orchards throughout the two growing seasons. These results have important implications for the export of apples to countries that are free of fire blight.

Five (Thunderbird, Profusion, Rosedale, Golden Hornet, and Hilleri) of eight crab apple cultivars budded to three apple rootstocks showed good resistance to blossom blight when inoculated during the blossom period with *Erwinia amylovora*. Except for Hilleri, the above cultivars were also resistant to shoot blight in tests performed in 1984 and 1985. The rootstocks did not appear to affect the susceptibility of the scion to fire blight. These results should be considered when selecting crab apples as interplanted pollenizers in apple orchards.

Apricot

Breeding. Nine new hybrid selections were made and propagated on Haggith rootstock seedlings for advanced trials in 1988. Each selection was a fresh market type and had satisfactory to good tree ratings for coldhardiness, productivity, and disease resistance combined with favorable fruit ratings for uniformity of ripening, attractiveness, size, and quality. Collectively they provided a fruit ripening sequence from 14 July to 31 July. Three other selections made previously, HW 444, HW 445, HW 446, were advanced to regional trials for the first time. Besides possessing adequate coldhardiness, productivity, and disease resistance, they also had attractive fruit of medium to large size and average to good flavor and texture.

Peach

Breeding. Eleven new hybrid selections were made and propagated on Siberian C peach seedlings for advanced trials in 1988. Selection criteria involved the evaluation of 15 tree and fruit characters including coldhardiness, productivity, and disease response as well as desirable fruit characters for the fresh market or processing. Collectively, these selections provided a fruit-ripening sequence from 24 July to 15 September. Eight of the selections were freestone, fresh-market types and three were clingstone processing types with firm, nonmelting flesh. Three other selections made previously, HW 253, HW 254, HW 255, were advanced to regional trials for the first time. They had good field ratings for tree vigor, productivity, and coldhardiness; above-average ratings for resistance to perennial canker, bacterial spot, and brown rot; and medium to good ratings for fruit type, attractiveness, and quality.

Effect of temperature and light on photosynthesis and internal water status. Three-year-old peach trees were subjected to photosynthetically active light levels of 444, 287, 144, 61, and 19 µmol ^{1}m^{2} and temperature ranges from 15 to 35°C under adequate water supply in a growth room. At very low light levels (19 and 61 µmol ^{1}m^{2}), the photosynthetic rate declined with increasing temperature. Multiple regression analyses for the three highest light levels showed that an increase in light increased the optimum temperature for both photosynthesis and stomatal conductance. The highest leaf-water potential was found at 21°C in all three light levels. The regression equations also showed that light was the main determinant of photosynthesis and stomatal conductance, but that temperature was the main determinant of leaf water potential.

Integrated orchard management. Three cultivars (Garnet Beauty, Harbrite, Canadian Harmony); two ground covers (temporary cover, permanent sod); and two irrigation treatments (drip, none) were studied in an experimental peach orchard established on Fox sand in 1980. The growing season in 1986 was unusually wet; nevertheless, plots under trickle irrigation in July and August had available soil water (ASW) levels that were 45% higher than nonirrigated plots. Under permanent sod, ASW was 8% lower than under temporary cover. There was a significant influence of cultivars on marketable yields in 1986, which were highest with Canadian Harmony (19.3 t/ha), intermediate with Harbrite (16.9 t/ha), and lowest with Garnet Beauty (10.3 t/ha). There was also a significant cultivar effect on yield of large-sized (>6.3 cm) fruit, which was highest with Canadian harmony (18.9 t/ha), intermediate with Harbrite (15.5 t/ha), and lowest with Garnet Beauty (8.0 t/ha), but neither ground cover nor irrigation treatments had an effect. Ground cover and irrigation treatments did not significantly influence marketable yields in 1986, but the yield of medium-sized fruit was increased.

Rootstocks. The first 5 years of data were summarized from a peach rootstock experiment comprising Redhaven as the scion tester and 10 peach seedling rootstocks: Bailey, Chui Lum Tao, H7338013, H7338016, H7338019, Halford, Harrow Blood, Lovell, Siberian C, and Tzim Pee Tao. Rootstocks differed significantly for their effect on the following scion characters: fruit set before thinning, total yield, marketable yield, yield of large-sized (>6.4 cm) fruit and split pits, time of defoliation, and cross-sectional area of the trunk. Highest yields in 1986 were associated with the following rootstocks: Halford, H7338019, H7338016, Lovell, and Chui Lum Tao (24.1–18.3 t/ha). Lowest yields were associated with the following rootstocks: Bailey, Tzim Pee Tao, Harrow Blood, and Siberian C (15.8–11.2 t/ha). Rootstocks that induced the most scion vigor also induced the highest yields.

Pear

Fire blight. Eight seedlings with good fresh-fruit quality were selected. The seedling trees had a level of fire blight resistance equal to Kieffer, and the fruit from the selections all had good ratings for appearance, freedom from grit, texture, flavor, and fruit size.

The experimental bactericide MBR 10995 (3M Corporation) was as effective as streptomycin in controlling the blossom blight phase of fire blight. CGA 78039 (Ciba-Geigy) and Copac E (BASF) along with MBR 10995 were effective in controlling shoot blight. As nonantibiotics, these materials could provide alternatives to streptomycin.

Modifications to Billing's predictive system were made to account for water availability and insect activity during the bloom period. The system was used to assess fire blight risk in six diverse fruit-growing areas of Ontario. Fire blight risk was much greater in the southwestern and Niagara areas of Ontario than in areas in the north and east. Within the regions, seasonal variability had substantial impact on the fire blight risk.

Rootstocks. Fruit production and growth of Bartlett and Harvest Queen were compared on five pear and one quince rootstock. Valid comparisons could not be made with the Bartlett trees because too many of them had died as a result of fire blight. Trees of Harvest Queen were not affected by fire blight to the same degree because of resistance to the disease. Harvest Queen trees on Old Home × Farmingdale (OH × F) 69 had the highest annual and accumulated yield, whereas trees on Quince A had the lowest annual yield, and those on OH × F 333 had the lowest accumulated yield. The largest trees were on OH × F 87, and the smallest were on Quince A. Trees on OH × F 69 were the most efficient (accumulated yield-trunk cross-sectional area), and OH × F 333 were the least efficient.

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Experimental Farm, Kapuskasing Ontario

PROFESSIONAL STAFF

J.G. Proulx, D.V.M.	Superintendent; Crop and beef management

Experimental Farm, Thunder Bay, Ont.

J. Wilson	Superintendent; Crop management and evaluation

INTRODUCTION

The Kapuskasing Experimental Farm has the mandate to conduct agricultural research for northern Ontario and northwestern Quebec. On 12 May 1986 the Kapuskasing Experimental Farm started to report directly to the director general of Ontario Region, and the Thunder Bay Experimental Farm to the superintendent of the Kapuskasing Experimental Farm.

Forage crop research supports the Ontario Forage Crop Committee and the Conseil de production végétale du Québec; as well, forage production methods and practices that are important for high-quality ruminant productivity are determined. In cooperation with scientists from the Plant Research Centre in Ottawa and Sainte-Foy, forage management practices that affect persistence of legumes and grasses are studied; the results can be found in the report from these establishments.

Cereal crop research supports the committees from Ontario and Quebec. Cultural practices for short-season growing areas have been determined, and resources are being shifted in support of soil research because soil and water management are believed to have most impact on yield. A 16-ha tile drainage project is being conducted in cooperation with the scientists from the Land Resource Research Centre (LRRC). To actively contribute to regional development, a project to solubilize rock phosphate by composting with local peat and liquid manure is being conducted in cooperation with other scientists from LRRC.

Beef cattle research is conducted in cooperation with scientists from the Animal Research Centre (ARC) in Ottawa. Researchers in ruminant nutrition are currently attempting to determine the influence of the form of protein that is present in forages, how it is influenced by cultural practices and preservation methods, and its impact on ruminant productivity. Similarly, research is being undertaken to determine the importance of the form of energy for ruminant productivity. More details on the beef cattle research program can be obtained from the pertinent section of the ARC report.

Further details can be obtained by directing your enquiries to the Kapuskasing Experimental Farm, Research Branch, Agriculture Canada, Kapuskasing, Ont. P5N 2X9; Tel. (705) 335-6148.

J.G. Proulx
Superintendent

FORAGE MANAGEMENT

Fall application of nitrogen on timothy

A total of 200/kg of N was applied to a stand of Champ timothy over a period of 5 years in a split application: 100 kg/ha in the spring plus 100 kg/ha after the first cut was compared with 50 kg/ha in the spring plus 50 kg/ha after cut one plus 100 kg/ha applied in the fall at different dates. Splitting the N application in three (spring, summer, and fall) resulted in 268 kg/ha of dry matter (DM) more than a two-way split (spring and summer) on the 5-year mean of the first cut. The effect was reversed on the second cut; the two-way N split outyielded the three-way N split by 550 kg/ha of DM. Similarly, the 5-year-mean total yield of the season was 282 kg/ha more on the two-way N split. First-cut yields were not affected by the date of the second cut the previous fall. Average DM yields of the second cut increased from a mean of 1539 kg/ha when harvested on 10 August to a high of 3288 on 30 September, and this difference was reflected on the season's total: DM yields increased from 6564 kg/ha to 8348 kg/ha. These results indicate that there was no advantage in applying part of the total N in the fall over conventional spring and midsummer application. Date of harvest at the second cut had no effect on the DM yield of the first cut of the following year; this suggests that timothy does not require a fall rest period as do alfalfa and clover.

CEREAL MANAGEMENT

Chemical desiccation of barley

Six different chemical treatments were evaluated and compared with a simulated swath in an attempt to reduce the moisture content of the barley crop before harvest. The six products used were Reglone (200 g/L), Gramoxone (200 g/L), Roundup (356 g/L), formic acid (85% solution), propionic acid (35% solution) and a sodium chloride solution (360 g/L). The moisture content at the time of spraying was 37.8%. The chemicals used reduced the moisture content of the grain to an average of 14.9%; the difference between the chemicals was not significant. The control treatment, which consisted of the simulated swath, reduced the moisture level in the grain to 11.8% during the same time interval. The 3-year adjusted grain yield, when adjusted to 15% moisture, ranged from a low of 4118 kg/ha to a high of 4388 kg/ha, which was not significantly different. This experiment demonstrated that there was no advantage in using a chemical as a desiccant to hasten maturity of barley. The simulated swath reduced the moisture content of the kernels faster and to a lower level than any of the chemical treatments.

EXPERIMENTAL FARM, THUNDER BAY, ONTARIO

Potatoes

Thirty-four cultivars of Elite I and II potatoes were grown to produce 3 t of seed potatoes at Elite II and III levels for Ontario regional potato trials. In the breeding program, selections were made from the 10-hill and single-hill trials; 10 000 tubers produced from true potato seed of 13 breeding lines were planted and 1887 tubers were selected for advancement to single hill trials. In the greenhouse 7700 tubers were produced from true potato seed grown from 10 breeding lines. Of 15 cultivars, 100 tubers were entered in Florida tests for indication of potato leaf roll virus (PLRV) and potato viruses M, X, and Y. All the material entered showed no presence of potato viruses M, X, or Y or PLRV.

Cereals

Cereal tests included Ontario regional oats and barley. The top-yielding barley was Leger at 2552 kg/ha, with Mingo a close second at 2527 kg/ha. The top-yielding oat was Cardinal at 1963 kg/ha, with Donald second at 1702 kg/ha. Yields were severely affected by adverse weather conditions in June.

Forages

The top-yielding early alfalfa cultivars in 1986 were entry 82.5 at 7009 kg/ha and N242-0 at 6880 kg/ha, compared with the checks Citation at 6433 kg/ha and Apica at 6188. For medium alfalfa, the top-yielding cultivars were CGA840-2 at 5532 kg/ha and OT83-1 at 5515 kg/ha, compared with the check cultivars 120 at 5252 kg/ha and Iroquois at 4870 kg/ha. The weather data for Thunder Bay during June and July showed a deficiency of precipitation of -24.1 mm and -24.8 mm, respectively.

Research Station, Vineland Station Ontario

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INTRODUCTION

The Vineland Research Station serves the horticultural industry with comprehensive crop protection research that is organized under four multidisciplinary programs: tree fruits, grapes and berries, vegetables, and ornamentals. Some work is also done on forages. Scientific disciplines represented at the station include entomology, acarology, ecology, mycology, virology, bacteriology, nematology, pesticide residue chemistry, toxicology, and computer science. The Smithfield Experimental Farm, located near Trenton, is administratively linked to the station and carries on horticultural production and processing research, as well as pest control programs, in collaboration with Vineland.

This report summarizes some of the research results from the station in 1986; more detailed information can be obtained from the publications listed at the end of the report. For more information on these or other research projects, or for copies of this report, please write to the Director, Research Station, Research Branch, Agriculture Canada, Vineland Station, Ont. L0R 2E0; Tel.(416)562-4113.

D.R. Menzies
Director

TREE FRUITS

Insects and mites

Biological control. Several pesticides applied for control of apple pests reduced levels of parasitism of eggs of the codling moth, *Cydia pomonella* (Linnaeus), and of the oriental fruit moth, *Grapholitha molesta* (Busck), after inundation with the parasites *Trichogramma minutum* Riley and *T. pretiosum* Riley. Two postbloom sprays of azinphosmethyl reduced parasitism levels from 29 to 16% and the emergence of parasites from sprayed eggs, from 0.9 to 0.5 per egg. Phosalone applied as a border spray to control adults of the apple maggot, *Rhagoletis pomonella* (Walsh), reduced levels of parasitism from 51.4 to 24.1%; and cyhexatin, applied for control of the European red mite, *Panonychus ulmi* (Koch), reduced parasitism levels from 77.6 to 23.2%. Application of the insect growth regulators diflubenzuron and alsystin, and the fungicides captan and polyram, had little effect on the levels of parasitism.

The ichneumonid *Phygadeuon wiesmanni* Sachtl., which parasitized pupae of the apple maggot, *Rhagoletis pomonella* (Walsh), in both the laboratory and field, also successfully attacked pupae of the cherry fruit fly, *Rhagoletis cingulata* (Loew), in the laboratory. Another species, *P. exiguus*, also imported from Europe, successfully attacked pupae of *R. pomonella*. There was some indication, particularly with *P. wiesmanni*, that parasitism levels were reduced in older pupae.

Chemical control. Resistance to pyrethroid insecticides, identified previously in adults of spotted tentiform leafminer *Phyllonorycter blancardella* (Fabricius), was shown to extend both to the egg and larval stages. Eggs of both resistant and susceptible strains were more susceptible to various pyrethroid insecticides than were larvae. Eggs treated 0–2 days postoviposition were more susceptible than 4- to 6-day-old eggs or larvae for both strains. Older larvae, especially from resistant strains, were less susceptible than early instars. For eggs and first-instar larvae, differences between resistant and susceptible strains were largely overcome by treatment with a higher concentration of permethrin. In the field, low levels of resistance were overcome by applications of permethrin with active ingredient (a.i.) at 212.5 g/ha diluted in 3370 L water and timed for first hatch of eggs.

The susceptibility of males and females of the parasite *Pholetesor ornigis* (Weed) to the pyrethroid insecticides permethrin, fenvalerate, and deltamethrin; to the organophosphorous insecticides azinphosmethyl and phosmet; and to the carbamate insecticide methomyl, was compared in the laboratory using two populations from Norfolk County, Ont. Female *P. ornigis* were more susceptible to permethrin than were males. There was no sexual difference in the susceptibility of *P. ornigis* to the other five insecticides tested. The results obtained for permethrin, fenvalerate, azinphosmethyl, and methomyl were compared with those obtained in the study completed 6 years earlier using *P. ornigis* from another location in Ontario. The results suggest that *P. ornigis* from Norfolk County have low levels of resistance to permethrin (3.3×), fenvalerate (2.2×), and methomyl (4.1×).

Ecology. The mullein plant bug, *Campylomma verbasci* (Meyer), was found to be a serious but intermittent pest of apples in the Okanagan Valley of British Columbia. Nymphs were first found in April or May during 1982–1984; apple and pear were the only overwintering hosts detected. On apple, the peak of first-generation emergence occurred an average of 11 days after full bloom, within 8 days of the appearance of the first nymphs. Two or three generations per year occurred on apple, and at least two generations were found on common mullein, *Verbascum thapsus* Linnaeus, the principal summer host. Mullein bug population levels were higher in pesticide-free and low-pesticide-use orchards than in other orchards, but the normal pesticide program for commercial apple orchards did not eliminate the pest. First-generation nymphs seriously damaged more than 1% of the apples in 17 of 40 samples, of four major varieties, examined at harvest in commercial orchards. The mullein bug was among the top three pests in 22 samples, with the damage most serious in Delicious cultivars. Field experiments revealed significant responses by males to females, female extracts, and captured volatiles, demonstrating the presence of a powerful sex pheromone, and showed that trap color or shape had significant effects on the catch of both sexes.

The European red mite, *Panonychus ulmi* (Koch), and the twospotted spider mite, *Tetranychus urticae* Koch, were common pests in 32 orchards of the major apple-growing districts of Ontario. Predatory mites were found in orchards where the use of insecticides for spotted tentiform leafminer was confined to the period before bloom, and levels of phytophagous mites were low in orchards with many predators. Apple orchards with serious mite problems had few mite predators and often had a record of heavy pesticide use during the previous year, primarily for midseason control of the spotted tentiform leafminer.

Nematodes

Rootstock assessment. Nine *Prunus* rootstocks including peach, plum, and peach × almond selections in a rootstock trial were sampled for nematode presence 2 years after planting. The site, a Brookston clay, was fumigated in the fall of 1983, planted in the spring of 1984, and sampled in the fall of 1985. All rootstocks were top grafted to Redhaven peach, and the plot was seeded to Italian ryegrass. Pin nematodes (*Pratylenchus projectus*) were ubiquitous in all replicates when sampled 2 years after fumigation. Rootstock selections are arranged in order, from least number of associated pin nematodes to greatest number, followed by mean number of nematodes per kilogram of soil, in parentheses: Siberian C (1430); Redhaven (1640); Lovell (1720); Bailey (2160); Damas-1869 (2170); GF655-2 (2310); GF677 (3410); Halford (5460); Citation (6070). The greatest number of nematodes per single replicate was 37 200 from a Citation tree-site. Of the nine selections, the lower mean number of nematodes was associated with two selections, Bailey and Siberian C, which are considered useful in Ontario for coldhardiness; the latter, however, is sensitive to root-lesion (*Pratylenchus*) nematodes. The results from the Halford and Citation, especially, show that the rate of multiplication of pin nematode following fumigation can permit rapid recolonization, demonstrating that tree-site fumigation, as currently practiced, is a short-term control measure.

Diseases

Peach canker, Leucostoma cincta, L. persoonii. Stems of 2-year-old peach cultivars, Candor (susceptible) and Sunhaven (relatively resistant), were inoculated in the greenhouse with mycelium of either *Leucostoma cincta* or *L. persoonii* and were subsequently sampled for histological study and pathogen reisolation. The cultivar Candor was initially colonized by both fungi more extensively than the cultivar Sunhaven. With time, cultivar differences were less important than differences in fungal virulence. Discontinuities or points of weakness in new periderms were detected in both wounded and inoculated samples. Sites of periderm circumvention and ingress by fungi into previously healthy tissues included the juncture of wound periderm with healthy periderm and with primary phloem fibers, and the nonsuberized centripetal surface of juvenile callus tissue. The expansion and coalescing of gum ducts caused the rupture of suberized xylem parenchyma boundaries, thus providing entry sites for the pathogens. Suberization of extant xylem ray parenchyma internal to wounds was observed in all wounded samples but in only one of nine inoculated samples. The results suggested that peach cultivars varied in their ability to establish anatomical barriers in bark and xylem and that *Leucostoma* spp. inhibited suberin deposition in xylem barrier zones.

Peach bark wounds of varying ages were inoculated with mycelium of *Cytospora leucostoma* (Pers.) Fr.; and frequency and extent of colonization were determined. Noninoculated wounds of similar ages and in close proximity to inoculated wounds were also sampled and examined histologically for morphological and histochemical changes associated with nonspecific plant defense reactions, including lignification, formation of ligno-suberized tissue, and new periderm. Results demonstrated that lignified and ligno-suberized tissues significantly decreased the rate of fungal colonization, whereas new periderm with at least three cells of thickness of the new phellem completely inhibited fungal colonization. The critical period regarding effective periderm formation was between 10 and 14 days postwounding.

Dissipation of captan residues. Mature sweet cherry, sour cherry, and peach trees were sprayed one to eight times with captan at 4.5 kg/ha (sweet cherries) and 2.4 kg/ha (sour cherry and peach). Captan residues on fruits were measured for 14 days after the last application and were negatively correlated with rainfall in seven of nine studies. Residues after the last application exceeded the accepted tolerance of 5 mg/kg in eight of nine treatments; the longest period for residues to decline below this level was 11 days for sweet cherry and 14 days for sour cherry and peach. Captan did not degrade on sweet cherries stored at 4 and 20°C but was easily removed with a 60-s tumbling wash in water. A captan tolerance of 10 mg/kg of cherry and peach fruits appears necessary to protect adequately against brown rot (*Monilinia fructicola*).

Fungicide synthesis. Three alkyl isocyanate homologues of benomyl were synthesized and compared for their toxicity toward benomyl-sensitive (S) and benomyl-resistant (R) isolates of *Botrytis cinerea* with the use of a spore germination test. For the inhibition of germ tube length, methyl (MBC-MIC), ethyl (MBC-EIC), and propyl isocyanate (MBC-PIC) homologues of benomyl were as effective against the S isolate as benomyl (MBC-BIC), but they were more fungitoxic than MBC-BIC toward the R isolate. MBC-MIC was equally effective in inhibiting spore germination of both the S and R isolates and was more effective than the other homologues against S isolate. MBC-EIC and MBC-PIC were more fungitoxic to the R than to the S isolate and thereby showed negative cross resistance to benomyl. For the protection of wounded apples, MBC-EIC was much more effective than benomyl against the R isolate and was only slightly less effective than benomyl against the S isolate. Accordingly, MBC-EIC and possibly MBC-MIC are benzimidazole compounds with potential for use against fungal isolates both sensitive and resistant to benomyl.

GRAPES AND SMALL FRUITS

Nematodes

Vectors. Xiphinema rivesi was recovered from all nematode-containing samples taken from 7 uninfected and 14 tomato ringspot virus (TmRSV)-infected European hybrid vineyards established in the Niagara region for 10 years or more on seven soil types, ranging from heavy clay to fine sandy-loam. *X. americanum* occurred in one sample. TmRSV-infected vineyards occurred on all soil types, and the virus was transmitted to bait plants grown in soil removed from infected vines. The results indicated that *X. rivesi* is the most probable vector of the virus in Niagara vineyards and that the nematode is associated with a wider variety of soil types than was previously reported.

Fumigants in strawberry propagation. The efficacies of several soil fumigants were evaluated for control of *Pratylenchus penetrans* in fields for strawberry plant propagation. Telone II-B, Telone C-17, Vorlex Plus, and Vorlex Plus CP fumigants at 110, 280, or 440 L/ha were applied in late October to replicated plots. Mother plants of Veestar strawberry were planted in May 1985 and grown until October, when mother crown survival, daughter plant production, and number of nematodes were determined. Growth of purslane and pigweed in plots was monitored throughout the growing season. None of the chemical treatments completely eliminated the nematodes; spring counts of number of nematodes at the lowest rate in Vorlex and Telone plots were 25 and 50% those of the untreated checks, respectively. The higher rates of fumigant were not sufficiently more effective to warrant their use. At 280 L/ha, all fumigants except Telone II-B reduced number of weeds by 66–88%; Telone II-B is chemically nematicidal, whereas the other products are general soil sterilants. Weed reduction was greater against purslane than pigweed. Mother crown survival increased by about 20% in the fumigated plots; daughter plant production increased in proportion with fumigant rate, yielding at least twice and up to 3.5 times the number of daughter plants as the untreated checks.

Diseases

Virus resistance. The influence of grapevine understock on the resistance of scion varieties to tomato ringspot virus (TomRSV) has been examined. DeChaunac grafted onto resistant understock and planted in an established vineyard with a history of TomRSV infection has been monitored over a 6-year period for evidence of scion infection. Resistant understock confers field resistance to DeChaunac and does not result in significant yield reduction of crop quality. DeChaunac controls grafted onto DeChaunac understock remained free of TomRSV over the 6 years, whereas own-rooted DeChaunac became infected early in the study. The graft union apparently plays an important role in limiting virus movement in the scion wood.

VEGETABLES

Insects

Chemical control of the carrot rust fly. Because carbofuran is microbially degraded in muck soils, alternative insecticides were tested for control of first-generation carrot rust fly (CRF) in furrow application by precision seeding. Phorate, terbufos, and fonofos, with a.i. at 2.2 kg/ha, all reduced CRF damage significantly, with fonofos having the least residue in the crop at harvest. As a possible alternative to these conventional insecticides, which may be difficult to register, the growth regulator cyromazine was tested by V-belt seeder application. The 3G formulation, with a.i. at 0.6, 1.0, and 1.4 kg/ha reduced CRF damage significantly.

Chemical attractants as aids for monitoring the carrot rust fly. Three compounds, constituents of carrot foliage and known to be attractive to CRF, were tested in carrot plantings at the Holland Marsh to determine their capacity to increase captures of adults on yellow sticky traps. The most effective material, aldehyde hexanal, when presented in small vials attached to the trap stakes, increased interim catches 1.7 to 25 times and total catches over a 6-week period by 3.5 times. When adult populations were low, hexanal-baited traps captured at least one fly about five times more frequently than nonbaited traps, indicating that the attractant could be a useful monitoring aid in such situations.

Diseases

Mycoherbicides. Mycoherbicides are being actively developed as a method of biological control in Canada and the United States. The mycoherbicide Collego and various *Colletotrichum* species were tested for latent colonization in tomatoes, soybeans, and several weeds by surface sterilizing followed by dipping fungus-inoculated plant material in paraquat. The paraquat technique enabled more accurate and more rapid host-range studies to be performed. The results indicated the need for proper testing of latency of fungal organisms used as mycoherbicides before registration is approved.

Phoma complanata. Canker of parsnips caused by *Phoma complanata* is an important constraint to parsnip production. Successful fungicide control measures as well as a disease severity – yield loss model were identified and developed for the first time in field tests at various sites in Ontario.

Control of the tomato spotted wilt virus. Paraffinic mineral oil is being tested for control of the thrips-transmitted tomato spotted wilt virus (TSWV) in vegetable and ornamental greenhouse crops. Both preinoculation and postinoculation sprays reduced number of lesions by as much as 90% in mechanically inoculated solanaceous hosts. Efficacy was dependent on both oil rate and time of application. The results indicated that control was related to oil toxicity to infected plant cells and that significant reductions in levels of infection could be achieved for several hours after inoculation. Maximum efficacy of postinoculation sprays occurred about 30 min after inoculation. In preliminary tests, oil sprays reduced the incidence of systemic infection in tomato plants by up to 35% when plants were openly exposed to cultures of viruliferous thrips. More efficient control may be possible by manipulating rates of oil and the spray schedule.

Turnip mosaic virus. The epidemiology of turnip mosaic virus (TuMV) was examined in Huron and Middlesex counties where heavy losses in rutabaga production have been experienced over the last 3 years. Field surveys demonstrated that the virus, overwintering in winter rapeseed, was transmitted by aphid into rutabaga plantings, resulting in poor crops and reduced root storability. A second strain of TuMV was identified in hosts of cruciferous weeds, although it was not infectious in rutabaga or rapeseed cultivars.

Control of Botrytis cinerea and Sclerotinia sclerotiorum. Various levels of carbon monoxide (2.5, 5, or 7.5%) in 1.5% oxygen were tested against gray mold (***Botrytis cinerea*** Pers.) and white mold (*Sclerotinia sclerotiorum* (Lib.) de Bary) rots of celery (*Apium graveolens* L. var. *dulce* DC.) stored at 0–1°C for 11 weeks. All levels controlled both diseases, but the best result was obtained with the 7.5% level and the poorest with the 2.5% level. Disease control with the 5% level did not differ from that with the 7.5%. On the other hand, none of the mixtures containing 4, 8, or 16% carbon dioxide in 1.5% oxygen gave effective control of gray mold rot on celery stored at 10°C for 3 weeks.

ORNAMENTALS

Insects

Frankliniella occidentalis. The western flower thrips, *F. occidentalis*, was detected in 20 of 23 greenhouses across Ontario where thrips control problems had been reported. The onion thrips, *Thrips tabaci*, was found exclusively in the other three greenhouses. *F. occidentalis* was collected from 19 different host plants within greenhouses and from 9 weed hosts outside, bordering greenhouses; it was also identified from greenhouse crops in Quebec and Nova Scotia. The tomato spotted wilt virus, transmitted by this insect, was found in six greenhouses in Ontario and caused extreme losses in crops of tomato, gloxinia, and impatiens.

Liriomyza trifolii and Pseudomonas cichorii on chrysanthemums. An interaction was found between the chrysanthemum leafminer and bacterial leafspot of florists' chrysanthemum. Stipples caused by oviposition and feeding of the leafminer were wound sites for bacterium infection. Plants exposed to the leafminers for 1 h immediately before inoculation developed an average of 68.1 spots per leaf compared with nonexposed plants, which developed only 6.4 spots per leaf. Over 93% of the stipples became infected after inoculation. A significant linear relationship was discovered between the number of stipples caused by the leafminer and the number of leaf spots that developed. Lower concentrations of the bacteria (as low as 10^3 colony-forming units (cfu) per millilitre) were effective in causing leaf spots on plants exposed to leafminer, whereas 10^7 cfu/mL was necessary on plants not exposed to the leafminer. The likelihood of infection of stipples decreased over a healing time of 4 days between exposure to the leafminer and inoculation. After 48 h, only half the stipples became infected. By 72 h or longer, the number of spots that developed was no longer significantly greater than the number of spots on nonexposed plants. All trends were tested on cultivar Manatee Iceberg, with similar results with Bright Golden Anne, Polaris, Amber, and White Marble.

Diseases

Botrytis tolerant of the fungicides iprodione and benomyl. *Botrytis cinerea* strains resistant to iprodione or benomyl were characterized by EC_{50} values for spore germination. Values for iprodione- and benomyl-resistant strains were 15 and 2800 mg/L, respectively, compared with 1 and 900 for the sensitive wild types. As expected, EC_{50} values for germination were 5 to 50 times greater than values previously reported for inhibition of mycelial growth. Resistance was not lost after more than 50 weekly transfers of actively growing cultures in the absence of the fungicide.

Control of fungicide-resistant Fusarium. Varying levels of resistance to benomyl were found in isolates of both *Fusarium oxysporum* and *F. solani*. Over 15% of all isolates tested showed some level of resistance. The isolates of both species were split into two groups according to their levels of resistance, and EC_{50} values for mycelial growth were determined in vitro. The EC_{50} values for sensitive and resistant *F. oxysporum* were 1.4 and 349.1 mg/L, respectively. Values for sensitive and resistant *F. solani* were 0.8 and 146.2 mg/L, respectively.

Multileadering of spruce. Multileadering in both spruce and pine seedlings was shown to be related to field management practices. Shading of first-year nursery stock significantly reduced multileadering. Tissues sampled from multileadered trees failed to identify any evidence of pathogen damage, and grafting studies demonstrated that multileadering symptoms were not graft transmissible. Multileadered trees, when removed from field compartments at the Midhurst tree farm, resumed normal growth within 3–4 years. Soil from field compartments with a previous history of multileadering failed to induce multileadering symptoms in either spruce or pine when trees were grown under a different management regime.

SMITHFIELD EXPERIMENTAL FARM

Apple scab, Venturia inaequalis. Sterol-inhibiting fungicides were ranked according to field performance in controlling *Venturia inaequalis* by reducing the number of conidia, spore germination, and germ tube length. Five fungicides were combined into three groups based on decreasing efficacy: DPX H 6573 and myclobutanil; bitertanol and triflumizole; and diniconazole. Fungicides in groups 1 and 2 provided better control of secondary field infection than captan, but only the materials in group 1 performed better than dodine. Diniconazole provided scab control of apple scab equivalent to captan but poorer than dodine.

Fire blight susceptibility of scab-resistant apple cultivars. Apple cultivars resistant to *Venturia inaequalis* were evaluated for susceptibility to five strains of *Erwinia amylovora* in field trials for 3 years. Macfree was relatively resistant. Moira was susceptible with a reaction to fire blight similar to McIntosh. Britegold, 0-637, Murray, and Trent were intermediate in susceptibility to fire blight based on response after field inoculation.

Apple cultivars grown on their own roots. Eleven cultivars of apple were rooted using softwood cuttings in a mist bed. Growth and productivity were compared with the same cultivars on the size-controlling rootstocks MM106, 0-8, 0-3, and *M. robusta* 5.

After 6 years in the orchard, cultivars on their own roots generally are more vigorous and less precocious than when grafted onto 0-3, MM106, or 0-8 rootstocks. Failure of trees on their own roots to set fruit has resulted in these trees continuing to grow at a rapid rate. Only one cultivar, the scab-resistant Moira, had a yield efficiency comparable to that of the grafted trees. Cultivars differ in productivity on their own roots, and evaluation will be required to select the most suitable for this type of production. Self-rooted Macspur are no more yield efficient than the two standard McIntosh strains tested.

Weed control in an established orchard. The lack of residual herbicides available to fruit growers prompted this study. The best overall weed control that was better than the standard paraquat plus simazine treatment was obtained with PPG 1013 and PPG 1259. Oxyfluorfen gave good control of broadleaved weeds but missed the grasses. Norflurazon gave good residual grass control, and RE 45601 gave good control of mature annual grasses. No injury to the trees was observed with any of these treatments.

Control of preharvest fruit drop of McIntosh. A comparison of daminozide, napthalene acetic acid, 2,4-dichlorprop, and PPG 1721 for controlling fruit drop in McIntosh demonstrated that daminozide was the most effective material. All materials were effective up to 25 September. By 1 October only 2,4-dichlorprop and daminozide had less fruit drop than the untreated trees.

Only the daminozide-treated fruit had lower ethylene production, a lower respiration rate, and delayed maturity measured by starch and pressure test when compared with the untreated control.

Sweet corn spacing trial. Yield of sweet corn has been increased in 2 years of testing by using narrower-row widths at a fixed population of 44 500 plants per hectare. In 1985 the yield of Jubilee was 25% higher at a

50-cm row spacing compared with a 91-cm row spacing. In 1986 the yield of Reward and Jubilee sweet corn was increased by 6 and 20%, respectively, from 90-cm rows to 76-cm rows. Cob measurements did not differ in either year from one row width to another. In 1986 more plants with marketable ears were produced in the 76-cm rows than in the 90-cm rows. The difference is attributed to a wider spacing within the row, thus improving light utilization.

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Prairie Region
Région des Prairies

W.L. Pelton

R.E. Howarth

J.E. Knipfel

D.I. Gourlay

Director General *Directeur général*	W.L. Pelton, B.S.A., M.S.A., Ph.D.
Program Specialist *Spécialiste en programmes*	R.E. Howarth, B.S.A., M.Sc., Ph.D.
Program Specialist *Spécialiste en programmes*	J.E. Knipfel, B.S.A., M.Sc., Ph.D.
Acting Chief, Administration *Chef de l'administration intérimaire*	D.I. Gourlay

PREFACE

The Prairie Region, with headquarters in Regina, Sask., consists of ten research stations, three experimental farms, and five substations. In 1986 the region managed a budget of $51.3 million and employed a staff of 1016. Substantial research programs were conducted in soil management and conservation, pest studies, beef, cereal grains, oilseeds, and forage crops, with smaller programs in water and climate, energy, engineering, biotechnology, environmental quality, dairy cattle, swine, poultry, sheep, bees, special crops, vegetables, ornamentals, food processing, and product storage.

The region participates in many joint and cooperative projects with provincial governments, universities, producer groups, commodity associations, and agribusiness. Notable among these are the Economic Regional Development Agreements with Manitoba and Saskatchewan, and the Farming for the Future program in Alberta.

Minimum and zero-till practices were studied as alternatives to conventional tillage systems, which often cause soil erosion, soil moisture loss, and deterioration of soil structure. For continuous zero-till spring wheat, the use of snow trap strips conserved extra moisture and increased wheat yields, especially in the drought years. Long-term nitrogen fertilization, combined with good soil management practices, aided replenishment of soil organic matter in both continuous wheat and fallow–wheat–wheat cropping systems.

Projects were conducted to reduce the use of chemical pesticides. Native and introduced parasites of insect pests were tested. The use of chemical insecticides on baits for the control of grasshoppers reduced the amount of insecticide by 75% and was safe to pollinating insects. A simple method was developed to determine the need for insecticidal control of pea aphids in field peas. Insect pests of knapweed are established at test sites and are reducing knapweed seed production. A fungus, which causes anthracnose of round leaf mallow, showed good potential as a bioherbicide and has been turned over to a private company for commercialization.

In 1986, the buildup of stem rust spores in the eastern prairies was the heaviest in over 30 years. Although the potential for diaster was high, there was no stem rust damage, except to winter wheat, because of the stem rust resistance in the recommended cultivars of spring wheat.

New crop cultivars licensed during 1986 included Roblin and Laura hard red spring wheat, Ellice malting barley, Barrier alfalfa, and the corn hybrid 810324. Two new apple cultivars, Fall Red and September Ruby, were released to the nursery trade. Research in plant genetics led to the identification of new genes for resistance to stem rust and true loose smut in barley. A method has been developed to remove glucosinolates from brown or oriental mustard, thus removing one constraint to the development of mustard as an edible oilseed crop.

Barley yields following pulse crops in a rotation were 21% greater than following barley. Seeding depth and seeding date were identified as important factors for successful overwintering of winter wheat. Herbicides were tested for the control of wild oats, quack grass, lamb's-quarters, stinkweed, and other weeds. Fertilizer and herbicide recommendations were developed for the major and special crops. Soil microorganisms, vesicular-arbuscular mycorrhizal fungi, increased dry matter production and nutrient uptake in wheat and beans.

Recommended practices for optimum breeding ability of bulls were developed and three-way crosses of beef cows were tested for overwintering feed requirements. The average lean contents of Canada A1 and A2 beef carcasses were 63.3% and 60.0%, respectively. Feeding trials established the nutritional value of 3M wheat for poultry, and of lentils and pea screening for swine. Six-row barley was more susceptible to mycotoxin formation than two-row barley. The causes of piglet death and lameness in swine and pale, soft, exudative (PSE) pork were investigated. Blast-chilling of carcasses produced fresh pork with a darker color and slightly firmer structure than carcasses chilled in a conventional manner.

During 1986, Dr. B.H. Sonntag was appointed director of the Swift Current Research Station and Dr. E.E. Swierstra was appointed director of the Brandon Research Station. Dr. D.L. Struble was appointed acting assistant director of the Lethbridge Research Station. At the Prairie Regional Headquarters, Dr. R.E. Howarth assumed duties as program specialist and Mr. D.I. Gourlay was appointed acting chief, Administration, replacing Mr. A.W. Strachan who transferred to the Food Production and Inspection Branch in Winnipeg.

Detailed information on the various programs may be obtained by writing to the establishments concerned or by addressing inquiries to Research Branch Headquarters, Agriculture Canada, Central Experimental Farm, Ottawa, Ont. K1A 0C5; Tel. (613) 995-7084.

W.L. Pelton
Director General

PRÉFACE

L'administration centrale de la Région des Prairies est située à Regina (Saskatchewan) et comprend dix stations de recherches, trois fermes expérimentales et cinq stations satellites. En 1986, la région gérait un budget de 51,3 millions de dollars et employait 1 016 personnes. Les chercheurs menaient des recherches considérables dans les domaines suivants: mise en valeur et conservation des sols; études sur les ravageurs; bovins de boucherie; céréales; oléagineux; cultures fourragères. Cependant, l'eau et le climat, l'énergie, le génie, la biotechnologie, la qualité de l'environnement, les bovins laitiers, les porcs, la volaille, les ovins, l'apiculture, les cultures de spécialité, les légumes, les plantes ornementales, la transformation des aliments et l'entreposage des produits ont également suscité l'intérêt des chercheurs.

La région participe à de nombreux projets mixtes et coopératifs avec les provinces, les universités, les groupes de producteurs, les associations du secteur primaire et l'agri-négoce. On peut citer, entre autres, sa contribution aux ententes de développement économique et régional conclues entre le Fédéral et le Manitoba et la Saskatchewan, et au programme *Farming for the Future* (L'agriculture de demain) de l'Alberta.

Les travaux ont également porté sur les pratiques de travail minimal ou de non travail du sol comme solutions de remplacement au système traditionnel qui provoque souvent l'érosion, la perte d'humidité et la détérioration de la structure des sols. Ainsi, pour la culture continue du blé de printemps sans travail du sol, l'utilisation de bandes-pièges à neige a permis de conserver plus d'humidité et d'accroître les rendements, en particulier pendant les années de sécheresse. Par ailleurs, l'épandage d'azote à long terme, allié à de bonnes pratiques d'aménagement du sol, a favorisé le renouvellement de la matière organique dans le sol, tant dans les systèmes de culture continue de blé que dans le régime de rotation jachère-blé-blé.

Les chercheurs ont également mené des travaux afin de réduire l'application de pesticides chimiques. Ils ont donc mis à l'essai des parasites indigènes et introduits d'insectes ravageurs. L'utilisation d'insecticides chimiques sur des appâts pour combattre les criquets a diminué la quantité d'insecticides de 75 % et protégé par le fait même les insectes pollinisateurs. Par ailleurs, les chercheurs ont mis au point une méthode simple pour déterminer les besoins en insecticides en vue d'éliminer le puceron du pois dans les grandes cultures. Ils ont aussi établi des populations d'insectes nuisibles au chardon dans des sites d'essais; ces insectes réduisent la production de graines chez cette espèce. Par ailleurs, un champignon responsable de l'anthracnose chez la mauve à feuilles rondes a donné d'assez bons résultats comme bioherbicide. On a par ailleurs demandé à une entreprise privée de le commercialiser.

En 1986, dans l'est des Prairies, on a enregistré la plus forte infestation par des spores de la rouille de la tige depuis plus de 30 ans. Même si les risques de désastre étaient très élevés, la maladie n'a pas causé de dommage sauf chez le blé d'hiver, car les cultivars recommandés de blé de printemps y résistent.

Parmi les nouveaux cultivars homologués en 1986, on compte les blés roux vitreux de printemps Roblin et Laura, l'orge de maltage Ellice, la luzerne Barrier et le maïs hybride 810324. Par ailleurs, les pépiniéristes ont diffusé deux nouveaux cultivars de pomme, Fall Red et September Ruby. La recherche en génétique végétale a permis d'identifier de nouveaux gènes pour la résistance à la rouille de la tige et au charbon nu chez l'orge. Les chercheurs ont mis au point une méthode susceptible d'éliminer, de la moutarde brune ou moutarde d'Inde, les glucosinolates qui empêchent actuellement de cultiver cette espèce comme oléagineux.

Les rendements de l'orge cultivé en rotation avec des cultures de légumineuses à grains ont augmenté de 21 % par rapport à la culture continue de l'orge. La profondeur et la date des semis sont considérées comme d'importants facteurs pour la survie hiémale du blé d'hiver. Les chercheurs ont mis à l'essai des herbicides pour lutter contre la folle avoine, le chiendent, le chénopode blanc, le tabouret des champs et d'autres mauvaises herbes. Ils ont ensuite recommandé des engrais et des herbicides pour les principales cultures et les cultures de spécialité. Des micro-organismes du sol et des mycorhizes vésiculaires-orbusculaires augmentent la production de matière sèche et l'ingestion des éléments nutritifs chez le blé et le haricot.

Les chercheurs ont recommandé des pratiques pour optimiser la capacité de reproduction des taureaux et ils ont effectué des croisements à trois voies des vaches de boucherie pour déterminer leurs besoins en aliments pendant l'hiver. Les teneurs moyennes en maigre des carcasses de boeuf Canada A1 et A2 s'élevaient à 63,3 et 60 % respectivement. Des essais d'alimentation ont permis de déterminer la valeur nutritive du blé 3M pour la volaille, ainsi que des criblures de lentilles et de pois pour les porcins. Par ailleurs, l'orge à six rangs semble plus sensible à la formation de mycotoxines que celui à deux rangs. Les chercheurs ont également essayé de trouver les causes de la mort et de la claudication des porcelets, ainsi que de la formation de viande exsudative. Les carcasses de porc frais refroidies par circulation d'air très froid sont plus foncées et légèrement plus fermes que celles qui ont été refroidies de manière traditionnelle.

En 1986, le D^{r} B.H. Sonntag a été nommé directeur de la Station de recherches de Swift Current et le D^{r} E.E. Swierstra, occupe le même poste à celle de Brandon. Le D^{r} D.L. Struble a obtenu le poste de directeur adjoint intérimaire de la Station de Lethbridge. A l'administration centrale de la Région des Prairies, le D^r R.E. Howarth a assumé les fonctions de spécialiste en programmes et M. D.I. Gourlay a été nommé chef intérimaire de la Section de l'administration où il remplace M. A.W. Strachan qui a été muté à la Direction générale de la production et de l'inspection des aliments à Winnipeg.

Pour obtenir de plus amples renseignements sur les divers programmes, il faut s'adresser aux établissements concernés ou envoyer la demande à l'administration centrale de la Direction générale de la recherche, Agriculture Canada, Ferme expérimentale centrale, Ottawa (Ontario), K1A 0C5. On peut également téléphoner au (613) 995-7084.

W.L. Pelton
Directeur général

Research Station, Brandon, Manitoba

PROFESSIONAL STAFF

Administration

E.E. Swierstra,[1] B.S.A., M.S.A., Ph.D.	Director
G.I. Johannson	Administrative Officer
S. Ramsay, B.Sc.(Agr.)	Information Officer
R.J. Bomford,[2] B.Sc., M.Sc.	Computer System Manager
E.D. Simundsson,[3] B.A., M.L.S.	Librarian
E.G. Smith,[4] B.S.A., M.Sc., Ph.D.	Economist (ERDA)

Animal Science

G.W. Rahnefeld, B.Sc., M.Sc., Ph.D.	Head of Section; Beef cattle breeding
A.G. Castell, B.Sc., M.Sc., Ph.D.	Swine nutrition
R.L. Cliplef, B.Sc., M.Sc., Ph.D.	Meats physiology
G.W. Dyck, B.S.A., M.Sc., Ph.D.	Swine reproductive physiology
R.R. Grandhi, B.V.Sc., M.Sc., Ph.D.	Swine nutrition
D.L. Grinwich,[5] B.Sc., M.Sc., Ph.D.	Swine reproductive physiology
R.M. McKay, B.Sc., B.S.A., M.Sc., Ph.D.	Swine genetics

Plant and Soil Science

L.D. Bailey, B.S.A., M.Sc., Ph.D.	Head of Section; Soil-plant relationships
P.N.P. Chow, B.Sc., M.Sc., Ph.D.	Herbicides and weed control
D.T. Gehl, B.S.A., M.Sc.	Agronomy (ERDA)
C.A. Grant,[6] B.S.A., M.Sc., Ph.D.	Agronomy
J.M. Sadler, B.Sc., M.Sc., Ph.D.	Soil fertility and plant nutrition
R.G. Simons, B.Sc., M.Sc., Ph.D.	Forage agronomy
M.C. Therrien, B.Sc., Ph.D.	Barley breeding and genetics

Departures

R.B. Irvine, B.S.A., Ph.D. Resigned October 1986	Barley physiology and agronomy
W.N. Migus, B.Sc., M.Sc., Ph.D. Resigned July 1986	Corn breeding and physiology
B.H. Sonntag, B.S.A., M.Sc., Ph.D. Transferred to Swift Current Research Station July 1986	Director

VISITING SCIENTIST

A.M. Hinshalwood, B.Sc., Ph.D. Postdoctorate fellow, February 1986 to February 1988	Adjuvant research

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[1] Appointed July 1986.
[2] Seconded from Systems and Consulting Directorate, Corporate Management Branch.
[3] Seconded from Libraries Division, Corporate Management Branch.
[4] Appointed May 1986 as an economist under the Canada–Manitoba agri-food agreement.
[5] On transfer of work at Animal Diseases Research Institute, Nepean, July 1986 to July 1987.
[6] Appointed November 1986.

INTRODUCTION

The Brandon Research Station is one of the five original experimental farms established by the federal government, and the year 1986 marked its centennial. The research station occupies 708 ha and leases another 585 ha for research work and feed production.

The present research program encompasses beef cattle breeding; swine nutrition, reproductive physiology, meats physiology, and genetics; barley and corn breeding; forage crop physiology; weed control in cereal, oilseed, and forage crops; and soil fertility, plant nutrition, and agronomy research. Research programs are designed to solve production problems and to evaluate new opportunities that will enable Canadian farmers, especially those located in the eastern prairie region, to maintain or improve their competitive position in domestic and foreign markets.

Dr. E.E. Swierstra became station director in August, replacing Dr. B.H. Sonntag who transferred to the Swift Current Research Station. Dr. E.G. Smith was appointed under the Canada–Manitoba agri-food agreement (Economic and Regional Development Agreement (ERDA)). He is responsible for economics research on crop and livestock production and soil management.

Dr. C.A. Grant obtained her doctorate degree and was appointed as a research scientist responsible for studies in soil management. Drs. R.B. Irvine and W.N. Migus resigned.

The short reports that follow give results of some recent research as well as an indication of the types of studies that are in progress. Further information may be obtained from publications listed at the end of these reports or by direct contact with scientists. Correspondence or requests for reprints should be addressed to the Research Station, Research Branch, Agriculture Canada, Box 610, Brandon, Man. R7A 5Z7; Tel. (204) 728-7234.

E.E. Swierstra
Director

ANIMAL SCIENCE

Beef cattle

Genetic effects on postweaning growth characteristics of three-way cross beef cattle. Genetic effects on postweaning growth traits were evaluated for 3592 crossbred steers and heifers fed at two locations, Brandon, Man., and Lacombe, Alta., during the period 1973–1978. The calves were sired by Chianina (Chi), Charolais (C), Limousin (L), and Simmental (S) bulls mated to 10 F_1 dam crosses representing the Hereford × Angus (HA) and nine other combinations produced by mating C, S, and L sires with H, A, and Shorthorn (N) females. Progeny rankings by terminal sire breed were C > L (5.3%), S > L (4.2%), and Chi > L (5%) for on-test weight and C > L (7.4%), S > L (5.7%), and Chi > L (6.8%) for off-test weight. For postweaning average daily gain, progeny rankings were C > Chi (2.4%), Chi > S (1.6%), and C > L (10.5%). Calves from the majority of exotic-cross dams were heavier on test and off test and had superior postweaning average daily gain than calves from HA dams. The largest progeny differences recorded for the breed cross of dam were SN > HA (11.2%) for on-test weight, SN > HA (8.6%) and CN > HA (8.2%) for off-test weight, and CN > HA (8.6%) for postweaning average daily gain. Ranking of dam crosses by the breed of dam's sire was S > C > L for weight on test and off test and C > S > L for postweaning average daily gain. Ranking of dam crosses by the breed of dam was N > H = A for on-test weight, off-test weight, and postweaning average daily gain.

Breed cross comparisons of beef cow productivity relative to winter feed inputs. Winter feed inputs as Mcal of digestible energy (DE) were measured over a period of approximately 147 days in each of four successive years for two herds of mature beef cows. Each herd, one located at Brandon, Man., and the other at Manyberries, Alta., included 10 breed crosses: the Hereford × Angus (HA), which served as a control, and nine others produced by mating Charolais (C), Simmental (S), and Limousin (L) sires with Angus (A), Hereford (H), and Shorthorn (N) dams. The feed data for analysis represented a total of 2994 cow years. Cow weight and condition were used for estimating daily feed allowances. Feed inputs were increased during periods of extreme cold, when deemed necessary to maintain cow condition or weight, and during the final 2 months of pregnancy. Cow efficiency was estimated by dividing Mcal DE per cow by the average weight (kilograms) of calf weaned in all breeding seasons prior to the change in winter management that was required for measuring feed consumption. Winter feed inputs at Manyberries averaged 16% higher than those at Brandon. Winter weight gains, approximately equivalent to the products of conception, were recorded at both locations. Manyberries cows had much lower fat levels at the start of the winter feeding period. Despite higher feed inputs, they still recorded substantial winter losses in average fat. Brandon cows had higher conception rates, lower calf mortality, and higher weaning weights. They averaged 16% above the Manyberries herd in lifetime productivity and were 47% better in cow efficiency. Breed cross rankings for winter feed inputs were C-cross > S-cross > L-cross > HA cows at both locations. These rankings closely mirrored differences in average cow weights. Most breed crosses, including the C-crosses and S-crosses, ranked well above the HA control in lifetime productivity for kilograms of calf weaned. For cow efficiency, the HA was approximately 8% more efficient than the CH and LA at Brandon and the LH at Manyberries, whereas the S-crosses at both locations and the C-crosses at Manyberries were more efficient than the HA.

Nongenetic influences on performance testing of beef cattle. Nongenetic influences on postweaning feedlot growth were evaluated for two genetically similar populations comprised of 4280 three-way cross calves at two locations with distinct feeding regimes. At one location, calves were full-fed an all-grain concentrate diet, whereas at the other location, energy levels in the diet were progressively increased through much of the feeding period. Two prediction methods, average daily gain (ADG) and regression of liveweight on age, were used to describe growth performance over 196 days. These methods were evaluated for accuracy when interpolating and extrapolating liveweights to fixed times relative to the start of the test.

There were substantial location, year, and sex effects as well as interactions involving location × year and sex × year for most of the postweaning growth traits.

No difference in accuracy of the prediction method was identified when calves were fed an all-concentrate diet. However, when calves were fed a progressively increased energy diet, ADG was more accurate than regression in describing growth. The accuracy of weight prediction was inversely related to the time between the end of the test and the target age.

The prediction technique used will not compromise the ranking of individual animals relative to their contemporaries. However, breeders want both an accurate ranking of animals and an accurate measure of an animal's advantage over its contemporaries.

Errors of prediction that result from the application of generalized statistical adjustments could be reduced through more rigid control of feeding and management practices and the age at test termination. However, the more realistic solution is to apply a specific adjustment to each animal that uses its own rate of gain during the test and its divergence in age from 365 days.

Economics of calf production with foreign beef cattle breed crosses in the parkland region of western Canada. The economic returns were determined for 31 three-breed crosses from a project that produced 2006 live births and 1930 weaned calves over a 6-year period at Brandon, Man. The calves were from Charolais (C), Simmental (S), Limousin (L), and Chianina (Chi) terminal sires bred to 10 first-cross dams, including the Hereford × Angus (HA) as a control and nine other combinations produced by mating C, S, and L bulls with H, A, and Shorthorn (N) cows. Economic factors considered were birth and weaning weights, calves weaned per dam (including conception and calving rates and calf deaths), longevity of the dam, calving difficulty, winter feed requirements for the breeding herd, and price premiums (discounts) for calves of specific breed crosses. The breed cross of dam was more important than the terminal sire breed in determining the profitability of the three-breed cross, but the terminal sire did have an effect. Simmental × Shorthorn and CA first-cross dams returned the highest net farm income. The HA and L first-cross dams returned the lowest income. The L and C terminal sires were the best. Annual net farm income differed by $130 per dam from the best to the poorest three-breed cross. This large variation in income illustrates the importance of the breeding herd's genetic component in determining the profitability of calf production.

Effect of carcass chill rate on tenderness. Three hundred and eighty-two crossbred steer and heifer carcasses, slaughtered over a 14-week period, were monitored to determine how the decline in internal muscle temperature or chill rate is affected by fat cover and carcass mass. As well, the resultant effects on shear values or tenderness were examined. Carcasses were separated into four different weight groups and also into four different fat level groups. There were no significant differences in color, texture, or marbling scores due to fat cover or sex. However, carcasses in the heavier weight groups tended to have higher marbling, texture, and firmness scores. Heavier carcasses had larger rib eyes and higher conformation scores as did steers when compared to heifers. Rounds and ribs of the heavier weight groups generally chilled slower than those of the lighter carcasses, but there were no significant differences in shear values. The chill rate of rounds did not differ between fat level groups. However, ribs from the higher fat level groups chilled more slowly than those from the lower ones. Lateral shear values from the lowest fat level group were significantly greater than those from the highest. Steer rounds and ribs chilled slower than those of heifers, and steer ribs sheared lower ($P < 0.05$) than those of heifers.

Swine

Prenatal and postnatal influences on growth and fat measurements in swine. Data from 153 foster groups, each consisting of a dam and a nurse, revealed that prenatal or direct genetic effects were the major factor in the determination of preweaning growth rate, weaning weight, postweaning average daily gain, postweaning allometric growth coefficient, and deposition curves for rib and loin fat. Postnatal influence was of minor importance and the prenatal × postnatal interaction was of negligible consequence. There were no significant differences between the Lacombe and Yorkshire breeds, first and second parity sows, and male and female piglets. This study indicated that fostering of piglets without regard for breed, parity, and sex of piglet would not seriously bias subsequent performance testing results.

Evaluation of lentils for pig diets. From 25 to 95 kg liveweight, male castrate pigs were self-fed 16% protein diets containing 0, 5, 10, or 20% cull lentils (cv. Laird, 23% protein). Only the 10% lentil diet improved ($P < 0.05$) live performance compared to the control (2457 versus 2579 g feed per day, 359 versus 342 g gain per kilogram of diet) and produced the leanest carcasses (15.7 mm backfat at 90 kg liveweight, 107.3 carcass value index). Evaluation of carcass loins by physical, chemical, and sensory methods revealed a higher meat quality in pigs fed the 10% lentil diet compared to the other dietary groups.

Utilization of pea screenings by market pigs. Screenings from two field pea cultivars, B.C. Blues and Century, were each included as 0, 11, 22, and 33% of diets fed ad libitum to 128 male castrate pigs from 25 to 93 kg average liveweight. Overall means with standard errors were 863 ± 7 g daily liveweight gain, 329 ± 3 g gain per kilogram of feed, 15.9 ± 0.2 mm backfat at 90 kg liveweight, and 103.2 ± 0.3 carcass value index. The lack of trends or significant ($P < 0.05$) effects from the inclusion of either type of screenings suggests that this by-product could adequately replace soybean meal in barley-based pig diets.

Dietary calcium-phosphorus levels and bone strength in gilts and sows. Various mechanical, physical, chemical, and histological characteristics of femur and third metacarpal bones were evaluated in 32 gilts and 46 second-litter sows. These pigs were fed 100% or 150% of 1979 National Research Council recommended levels of calcium (Ca) and phosphorus (P) during finishing, gestation, and lactation. Feeding higher Ca–P levels during finishing increased ($P < 0.05$) the bone shaft diameter (23.2 ± 0.2 versus 22.3 ± 0.2 mm) in femurs and the percentage of bone ash (60.5 ± 0.4 versus 59.0 ± 0.4%) and percentage of bone Ca (19.0 ± 0.5 versus 17.0 ± 0.5%) in third metacarpals of gilts. Feeding higher Ca–P levels during gestation and lactation produced some positive changes in bone strength and certain other parameters. Histological examination of the sixth rib bones revealed no abnormalities in trabecular and cartilage structures between sows fed different Ca–P levels. Several bone characteristics were different between Lacombe and Yorkshire breeds, and their response to dietary Ca–P levels varied between femur and third metacarpals of gilts and sows.

Toe length disparity and its relation to nutrition and lameness in boars, barrows, and sows. The front and hind feet from a total of 64 boars, 86 sows, and 107 barrows were radiographed after necropsy to study the nature of toe length disparity. Radiographs of metacarpals, metatarsals, and associated phalanges were measured for length and deviations of the proximal and distal extremities. The incidence of toe length disparity with a smaller medial digit was 90.9% in boars, 96.7% in sows, and 87.6% in barrows. In front feet, toe length disparity was due to lower positioning of the proximal extremities of lateral bones, whereas in hind feet, this condition was due to longer lateral bones. Dietary levels of energy, calcium and phosphorus, vitamins, or sodium did not affect the incidence of toe length disparity. A poor correlation between structural soundness scores and the lengths and deviations of foot bones indicated that toe length disparity was not a primary cause for lameness in boars and sows.

Causes of piglet death from birth to weaning. The causes of death were determined for 569 piglets that died out of 2388 born over the second to fourth parity in Yorkshire and Yorkshire × Lacombe sow litters. Starvation, crushing by the sow, and stillbirth were the three main causes. Unidentified causes and euthanization largely due to sow death or injury were of secondary importance. Exposure, congenital abnormality, and disease were of minor importance. The primary underlying cause of death appeared to be a lack of adequate nutrition for the piglets. Only 6.3% of the piglets dying during the first 3 days had an increase in body weight, and only 15.4% of the piglets dying after the 3rd day had weight gains that could be considered adequate for their age.

Puberty attainment in the gilt as affected by age at relocation and mature boar contact. Three groups of 34 gilts each were relocated and exposed to mature boars (constant fence line and full contact for 30 min a day) at 160, 180, or 200 days of age. The gilts were mated at pubertal estrus and slaughtered 21 days later. The mean time from relocation to puberty (11.4, 9.4, and 5.9 days, respectively) was less ($P < 0.05$) for the oldest gilts. However, age at puberty increased ($P < 0.01$) with each older age group (177, 192, and 207 days of age, respectively). Conception rate, ovulation rate, and the number of embryos were not significantly affected by age at relocation (84%, 11.3, 9.2; 96%, 10.3, 9.0; and 92%, 10.6, 8.7, respectively).

Puberty attainment in the gilt following various degrees of mature boar contact during rearing. At 70 days of age, 144 gilts were assigned to three levels of boar contact: fence line, olfactory and aural, and none. At 160 days of age, the gilts were relocated adjacent to a mature boar with which they were given full contact for 30 min a day. One third of the gilts from each treatment were mated at either the first, second, or third estrus and then slaughtered 21 days later. Age at puberty was similar for all three rearing treatments (184, 180, and 181 days, respectively). Ovulation rate and the number of embryos were not significantly affected by either the rearing treatment (11.9, 10.0; 11.9, 9.6; and 12.1, 9.5, respectively) or time of mating (11.6, 9.6; 12.1, 9.4; and 12.2, 10.1, respectively).

PLANT AND SOIL SCIENCE

Cereals

Barley breeding and physiology. A new gene for resistance to true loose smut (*Ustilago nuda* (Jens.) Rostr.) in barley has been mapped on linkage group VII. The source of this new form of resistance is the Ethiopian biotype CI 9973. The symbol *Run2* is being proposed for this gene, which is linked to the $cer\text{-}b^2$ (waxy) gene with a recombination frequency of 18.6%. The trait is monogenic dominant and can be transferred into a wide spectrum of barley genotypes.

Longer intracoleoptilar internode length (ICI) in barley was found to conserve subsoil moisture use under drought conditions. However, genotypes with increased ICI did not produce significant yield advantages over those with standard ICI when moisture stress occurred in the field. This trait, therefore, appears to be of little value in screening for drought-resistant genotypes.

Trifluralin proved useful in simulating a droughty environment for barley. This herbicide is nearly immobile in the soil and can form an effective treatment layer. When placed at a depth of 30 cm, trifluralin prevented root penetration below the treatment layer without affecting roots above it or top growth. Therefore, moisture use was restricted to the zone above the treatment layer. This method has potential in screening for barley genotypes that tolerate or avoid drought.

Corn breeding. Three Brandon hybrids, 810324, 820498, and 820278, were found to mature the earliest of all entries tested in 1986. They have good yields and agronomic characteristics and are adapted to the 2000 corn heat unit regions. Hybrid 810324 was supported for registration. The other two hybrids will be retested in 1987, because their populations were low in 1986 as a result of poor seed from the winter nursery in Florida.

Forages

Alfalfa emergence under low temperature and deep seeding. A controlled-environment experiment studied the effect of temperature and seeding depth on the emergence of eight alfalfa cultivars. Over the treatments as a whole, Algonquin had the best emergence, after correcting for differences in seed viability. Cultivars with heavy seeds did not emerge better than those with light seeds. Vernal and Iroquois were the most affected by deep seeding, and Citation was the least affected. Citation was also the least affected by low soil temperature, and Banner and Saranac were the most affected.

Soil management and crop production

Fertility requirements of sorghum. A 3-year field study examined the fertility requirements of sorghum on Manitoba soils deficient in nitrogen. The application of nitrogen at rates up to 120 kg/ha increased sorghum yields by 0–54% and 20–65% under conditions of inadequate and sufficient moisture, respectively. These results were used in formulating nitrogen fertilizer recommendations for sorghum in the province.

Weed control. Fall application of a premixture of triallate (1.1 kg/ha) and trifluralin (1.4 kg/ha) gave good control of wild oats and lamb's-quarters and significant increases in wheat yield over the untreated checks. Spring application of the premixture did not perform as well. Mixtures of AC 222 293 (0.25 kg/ha) with several broadleaf weed herbicides compared favorably to single applications of the grasskiller; neither wild oat control nor wheat yield was reduced. Similarly, single applications of diclofop-methyl or flamprop-methyl performed as well as mixtures of these chemicals with DPX M6316, L5300, and R9674. Other grasskillers, PP 606 and FOE 3440A, consistently showed good control of wild oats and green foxtail and increases in wheat yield. All of these new herbicides required the addition of appropriate adjuvants (0.25–0.5% by volume) to boost their activity on grassy weeds. Glyphosate at one half of the normal rate (0.45 kg/ha) gave excellent control of volunteer barley and weeds when it was applied alone or in combination with each of seven surfactants (0.5% by volume).

Wild oat control with RE 45601 (0.075 kg/ha) was enhanced by the addition of each of eight surfactants, resulting in greater rapeseed yield. However, the surfactant X-77 stunted development of the crop during the early growth stage. BAS 517 (0.075–0.1 kg/ha) showed excellent control of wild oats and increases in rapeseed yield over the checks. When HOE 33171 (0.25 kg/ha) was mixed with bromoxynil, grassy and broadleaf weed control was improved in flax. Such was not the case when bromoxynil/4-chloro-2-methylphenoxyacetic acid (MCPA) was added; there was an antagonistic effect on wild oat control with mixtures of these two chemicals. RE 45601 gave good control of wild oats and green foxtail, even in cases of heavy infestation. However, its activity on wild oats was reduced when the chemical (0.075 kg/ha) was combined with several broadleaf weed herbicides, except for mixtures with MCPA and bromoxynil/MCPA.

In a small-plot test, sethoxydim plus the adjuvant Assist Oil or ammonium sulfate considerably reduced the dry weight of top growth and rhizomes of quack grass.

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Research Station, Morden, Manitoba

PROFESSIONAL STAFF

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H.G. Brodie	Administrative Officer
M.P. Reimer	Information Officer

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C.G. Campbell, B.S.A., M.Sc., Ph.D.	Breeding of buckwheat
G.H. Gubbels, B.S.A., M.Sc., Ph.D.	Crop management; Physiology
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R.C. Zimmer, B.Sc., Ph.D.	Diseases of field peas

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C.G. Davidson, B.S.A., M.Sc., Ph.D.	Breeding of woody ornamentals
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B. Siemens, B.S.A., M.Sc.	Potato storage
D.A. Wall,[2] B.S.A., M.Sc.	Weed control

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E.O. Kenaschuk, M.Sc., Ph.D.	Head of Section; Breeding of flax
W. Dedio, B.S.A., M.Sc., Ph.D.	Breeding of sunflowers
J.A. Hoes, B.S.A., M.S.A., Ph.D.	Pathology of flax and sunflowers

Departure

J.E. Giesbrecht, B.S.A., M.Sc., Ph.D. Resigned September 1986	Breeding of grain corn

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K.S. Kayande, B.Sc., M.Sc., Ph.D. Agronomist, Dryland Research Project, Punjabrao Krishi Vidyapeeth, Akola, Maharashtra State, India	Agronomist, dryland

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[1] Seconded for a 2-year term to the Priorities and Strategies Directorate, Ottawa, Ont.
[2] On educational leave.

INTRODUCTION

The programs at the Morden Research Station are directed toward the development of new cultivars and the improvement of management practices for buckwheat, field corn, field peas, new crops, flax, sunflowers, potatoes, vegetables, and herbaceous and woody ornamentals. This report summarizes some of the results obtained from research conducted during 1986.

Two new hardy apple cultivars and one nonoil sunflower hybrid were released. New information was obtained on the agronomic performance of flax blends, on the genetics of plant disease, and on the genetics of flower color and extra petals in *Potentilla*. Several ornamental plants were recommended to the nursery trade. Boyne raspberry, a cultivar released in 1960, was honored with an Outstanding Cultivar Award from the Canadian Society of Horticultural Science.

Further information on any of these research activities, reprints of publications listed in this report, and copies of previous reports may be obtained from the Research Station, Research Branch, Agriculture Canada, P.O. Box 3001, Morden, Man. ROG 1JO; Tel. (204) 822-4471.

D.K. McBeath
Director

FIELD CROPS

Buckwheat

Pathology. Buckwheat plants were shown to be systemically infected by the downy mildew (DM) pathogen, *Peronospora ducometi*. Two types of DM hyphae were observed, a large-diameter, non-branching type, and a narrow-diameter, branching type with numerous haustoria. The large-diameter hypha occurred in non-stunted buckwheat seedlings, whereas the branching hypha and haustoria formation was observed only in stunted plants. Systemic hyphae of the DM pathogen occurred in the petioles, flowers, and seeds of naturally infected plants.

Weed control. For the control of broadleaved weeds, the most effective treatment was fluorochloridone applied to the soil surface and left unincorporated.

Field corn

Weed control. DPX-M6316 (Dupont) and SC-5676 (Stauffer) were identified as potential herbicides to replace atrazine. The selectivity of clopyradlid for Canada thistle control in field corn was confirmed.

Field peas

Breeding. Pedigreed seed of the semi-leafless cultivar, Tipu, was released through SeCan to 130 growers in Manitoba and Saskatchewan. In spite of poor weather and low seeding rates used by growers, favorable reports were received on yield, standing ability, and ease of harvest. A project funded by Agri-Food agreement demonstrated to growers the advantages of growing semi-leafless cultivars.

An initial increase of the cultivar Titan produced 3000 kg of seed, which will be released to growers in 1987 through SeCan.

The use of fiber from field peas is increasing in high fiber foods. Tara peas were identified as having a high percentage of seed coat (8.8%) and thus a high fiber content. With their high yielding ability, they produced an average yield of seed coat of 220 kg/ha between 1981 and 1985.

Pathology. The development over time of powdery mildew (PM) on field peas may follow more than one profile. Some cultivars such as Century, Trapper, and Titan showed a low level of infection, 4–7%, at the first assessment, whereas 2 weeks later the infection level was 23–40%. Lenca and Tipu showed a similar low infection level at the first assessment but developed an infection level of 53–60% after an additional 2 weeks. A third profile group, Bellevue and SV09541, also showed a low infection level initially but increased to between 77 and 82% 2 weeks later. A fourth profile group, SV20565 and Triumph, showed a higher infection level (15–21%), and increased to 80–82% after an additional 2 weeks. Other data indicate that the date of first appearance of PM could not be used to predict the ultimate reaction of a line to the disease.

Weed control. HOE 033171 (Hoechst) was effective for the control of wild oats and green foxtail in field peas, but excessively high rates were required to control volunteer cereals. Tipu, a semi-leafless cultivar, was equal to Century in tolerance to most herbicides.

NEW CROPS

Weed control. Trifluralin and ethalfluralin were selective for broad spectrum weed control in safflower. Wild mustard in safflower was controlled with EL107 (Elanco), AC 222293 (Cyanamid), desmedipham, or fluorochloridone.

OILSEED CROPS

Flax

Pathology. In studies on postseedling resistance (PSR) in flax, the reactions of commercial cultivars and of 10 near-isogenic lines were determined to two or three of the virulent exotic rust races 22, 79, 191, and 218S61. The lines are of similar genetic background except that each carries one of 10 different genes that conditions resistance to specific races of the rust pathogen. Analysis of variance showed that the effects of races, cultivars, and race × cultivar interaction were all highly significant. Races differentiated among cultivars, whereas cultivars differentiated among races. The near-isogenic lines were more often differentiated by race 22 than by race 191, whereas cultivars were not differentiated by race 218S61. Commercial cultivars generally reacted more severely to race 22 than to race 79, races that are virulent to 26 and 15, respectively, of the 29 known resistant genes. The cultivars Summit (N^1) and Bison (L^9) were highly susceptible to both races, whereas Noralta and Redwood 65, both carrying gene N^1, showed less susceptibility. However, cultivars with resistance conditioned by genes K^1 and/or L^6 (Culbert, McGregor, NorMan, Raja), showed levels of PSR that were near-immunity and whose disease indices did not differ significantly from zero as in the cultivar Linott, which is immune to race 79. The data indicated highly significant nonlinear regression of both PSR to race 79 and PSR to race 191 on PSR to race 22. The correlation between PSR to races 191 and 218S61 was linear, however.

Management. Blends of flax cultivars generally stabilized production by yielding about midway between the yields of the components grown in pure stands. The blends demonstrated no advantage over growing the components in separate fields. However, when one of the components yielded very poorly in pure stands because of poor emergence, the stronger component compensated enough for the blend to produce an acceptable yield.

Weed control. Acceptable control of lady's-thumb resulted when bromoxynil/4-chloro-2-methylphenoxyacetic acid (MCPA) mixtures were applied when flax was 3–8 cm in height. DPX M6316 (Dupont) or cyanazine/MCPA were also effective for the control of hard-to-kill, broad-leaved weeds.

Sunflowers

Breeding. A nonoilseed sunflower hybrid, Morden 401, was recommended for licensing and has been released to a seed company for hybrid seed production. This hybrid matures at least 1 week earlier than other nonoil cultivars. Its yields are comparable to other cultivars when seeded late or when grown in fringe areas of cultivation. It is small-seeded compared to other cultivars and is suitable for use as birdseed. It has a high nutmeat content and high test weight.

Bird resistant sunflower hybrids, developed from three North Dakota bird resistant synthetics, showed yield loss from bird damage of only 2%, compared with 12% for commercial hybrids when tested at Morden. At Portage la Prairie, an identical test was completely destroyed by birds. The yields at Morden of bird-resistant hybrids were greater than the original synthetics, and one-third of the hybrids outyielded the best commercial hybrid. The time required for the bird-resistant hybrids to mature was less and the oil content was higher.

Weed control. EL107 (Elanco) applied in the fall was equal to spring applications for the control of wild mustard. AC 222293 (Cyanamid) applied at the two- to six-leaf stage of sunflowers resulted in almost complete control of wild mustard with acceptable crop tolerance.

HORTICULTURAL CROPS

Ornamentals

Breeding and evaluation. Several selections of various ornamental plants showed good potential. A pale pink rose selection has had continued good performance. Out of 20 red-flowered chrysanthemum selections made in 1985, two appeared to be very good. A population of open-pollinated seedlings of *Monarda* 'Marshalls Delight' yielded three dwarf plants, a valuable characteristic that would extend the usefulness of this plant as a landscape ornamental. *Sedum spectabile* 'Autumn Joy' and *Molinia caerulea* 'Variegata' were recommended to the nursery trade as hardy, pest-free, and attractive herbaceous perennials. Plants of *Aster sedifolius* and its cultivar Nanus were promoted and distributed to the nursery trade.

Canopy shape classification and analysis of *Fraxinus pennsylvanica* (green ash) was conducted by analyzing data with multivariate and univariate statistics. Three canopy shapes were identified: group A, which was tall and conical; group B, which was intermediate; and group C, which was broad and round. Green ash is dioecious. Sex type had little effect on canopy shape classification; however, male trees tended to be larger and appeared to be fuller with denser foliage than females. Male trees seem better suited for use as shade trees.

Inheritance models for flower color and extra petals (double-flowered) were determined for *Potentilla fruticosa* (shrubby cinquefoil). Superior selections bearing double flowers and/or cyanic flower colors were identified.

Fruit

Two apple cultivars were released. The crosses were originally made at Morden and evaluations were completed by the Prairie Fruit Breeding Cooperative. Seedlings were first selected at one of eight test sites across the prairies and then evaluated at the Alberta Horticulture Research Centre, Brooks, Alta., and the Agriculture Canada research stations at Melfort, Saskatchewan, and Morden. Fall Red and September Ruby were selected as widely adapted, good quality and excellent storing apples. Both plants are hardy to zone 2a of the Agriculture Canada map of plant hardiness zones in Canada. September Ruby was originally selected at the Agriculture Canada research station at Beaverlodge, Alta., whereas Fall Red was originally selected at the University of Alberta.

Superior lines of primo-cane and biennial types of raspberries were identified and are being advanced to a regional trial.

Boyne raspberry, released in 1960, was granted an Outstanding Cultivar Award by the Canadian Society of Horticulture Science at its 1986 meeting.

Potatoes

Management. Total and marketable tuber yields of Conestoga potatoes increased when harvest was delayed from 75 to 85 and 95 days after planting (DAP). Tuber yields increased with closer in-row spacing from 46 to 22 cm between seedpieces. Yields and tuber size varied with the growing season. Oversize tubers were found at only 95 DAP in 1982, at 85 and 95 DAP in 1984, and at all three harvest dates in 1986. Color of chips was acceptable at all harvest dates in all years and tended to improve with later harvest. Specific gravity increased with later harvest and tended to decrease with wider in-row spacing of seedpieces. The incidence of hollow heart in maingrade tubers was very low (0–1%) in 1982, undetected in 1983 and 1984, and severe (0–45%) in 1986. The severe incidence of hollow heart observed in 1986 may be related to the rapid increase in size of tubers that occurred that year. Some bitterness was detected in chips in 1984 and in boiled tubers in 1986.

Small tubers, 3.5–10.0 g in weight, from single-node stem cuttings of four cultivars of potato, Carlton, Conestoga, Tolaas, and NDA 8694-3, were tested with various treatments to break dormancy as a step in rapid greenhouse propagation. Dipping tubers, from which a small portion of the stem end had been removed (wounded), into a 10^{-5} m gibberellic acid solution for 1 h prior to planting, resulted in significantly earlier emergence than all other treatments for all cultivars. This treatment also resulted in the greatest yield of tubers per plant for all cultivars except Conestoga. With Conestoga, the greatest yield of tubers per plant resulted from wounded tubers dipped in distilled water for 1 h prior to planting. The greatest number of tubers per plant were produced when wounded tubers of Tolaas and NDA 8694-3 were dipped in gibberellic acid solution, when wounded tubers of Conestoga were dipped in distilled water, and when whole tubers of Carlton were dipped in gibberellic acid solution.

Utilization and quality

Saskatoon berries. High-performance liquid chromatography (HPLC), equipped with photodiode array detector, was applied to separation and concentration of the anthocyanins and related compounds of saskatoon berries. Thirteen discrete peaks were detected and separation of these took less than 40 min. Ten of the 13 HPLC peaks were collected as separate fractions from the column outlet and reanalyzed by paper chromatography and spectral analysis. The concentration of total anthocyanins was 86–125 mg/100 g of fresh berries. The main anthocyanins were cyanidin 3-galactoside, which formed 61%, and cyanidin 3-glucoside, which accounted for 21% of the total anthocyanins. Also identified were cyanindin 3-xyloside, chlorogenic acid, and rutin.

Buckwheat. A modified procedure for measuring nonenzymatic browning of buckwheat groats was developed. The procedure is based on extraction of soluble colored materials, clarification of the resultant extracts, and spectrophotometric evaluation of the extracted color. Using buckwheat groats subjected to high storage temperatures, browning results obtained by this procedure were compared to surface color of the groats determined with a Hunterlab tristimulus colorimeter. The correlation coefficients between absorbance of the extracted color at 420 nm and International Commission for Illumination tristimulus values, X, Y, and Z, were –0.966, –0.914, and –0.947, and those between absorbance and Hunter L, a, and b values were –0.974, 0.970, and –0.901, respectively. When the modified procedure was used to investigate the influence of water activity on nonenzymatic browning of buckwheat groats, it was found that minimum production of pigments occurred at water activities corresponding to the monolayer moisture content.

Peas. The moisture sorption isotherms of raw and precooked Century, MP 888, and MP 889 peas at 10, 25, and 40°C were determined by the standard salt solution technique. Pea cultivars, although different in composition, did not differ in equilibrium moisture content. At 40°C and in the water activity range $0.50 \leq a_w \leq 0.90$, the sorption capacity of raw peas was higher than that of precooked peas. The monolayer moisture content of precooked dehydrated peas stored at 40°C was 6.2%, with corresponding equilibrium relative humidity value of about 27%.

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D.J. Samborski, B.S.A., M.Sc., Ph.D. Retired 8 August 1986	Wheat leaf rust
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INTRODUCTION

Research programs at the Winnipeg Research Station focus on three main areas of responsibility: the development of improved cultivars of cereals specifically adapted to the "rust area" of the eastern prairies; research on the protection of stored cereals, oilseeds, and their products; and research on the integrated control of insect pests of field crops. In each of these areas, interdisciplinary teams of scientists are pursuing both mission-oriented and basic research.

Improvement of cereal cultivars requires the close collaboration of plant breeders, geneticists, cytogeneticists, plant pathologists, and cereal chemists. As a result of such collaboration, a new malting barley, Ellice, and the hard red spring wheat, Roblin, were registered in 1986. Ellice combines good agronomic performance and resistance to stem rust with unique enzyme systems that shorten malting time. Roblin features a higher average protein level than Neepawa, thus increasing the probability of producers' crops qualifying for the higher protein premium.

Our research on the storage and protection of cereals, oilseeds, and their products is national in scope and involves close cooperation with the Canadian Grain Commission, the Food Production and Inspection Branch of Agriculture Canada, and the grain industry. Particular emphasis is being placed on understanding the ecology of organisms infesting stored grain, the development of safe storage guidelines, chemical and physical measures to control infestations, and the microbiological and environmental factors influencing the occurrence of mycotoxins. Attention is being focused on controlling storage insects with minimal use of chemicals and improved means of detecting infestations. In this regard, Canadian Patents and Development Limited has recently licensed Agrobiotech International Limited, Winnipeg, to commercially produce a simple, inexpensive trap for monitoring insect infestations in grain that is based on a prototype developed at the station.

Research on the integrated control of field crop insects, particularly those that attack canola and the various "special crops" grown in southern Manitoba, includes the biology and ecology of pest species, the evaluation of biological and chemical control measures, the assessment of economic damage, and the development of integrated management systems. A recently developed sampling plan to assess population levels of pea aphids in field peas will provide growers with a rapid and accurate method for determining the need for insecticide control.

During 1986, Dr. D. Leisle, head of the Cereal Breeding Section, was awarded an honorary life membership by the Manitoba Branch of the Canadian Seed Growers' Association, for his outstanding contributions to the seed industry; Dr. D.J. Samborski, wheat leaf rust pathologist, was honored with a Distinguished Graduate in Agriculture Award by the University of Saskatchewan and with an Outstanding Research Award by the Canadian Phytopathological Society; and Dr. D.R. Metcalfe, barley breeder, was recognized for his contributions to barley improvement at the Triennial Barley Workers meeting. Staff were saddened by the deaths of two good friends and former colleagues: Dr. L.B. Smith, who died suddenly shortly after his retirement, and Mr. R. Bristow, a long-time technician in the Cereal Breeding Section.

In 1986, over 87% of the area sown to hard red spring wheat across the prairies was sown to cultivars developed at the Winnipeg Research Station. These and other disease-resistant cereal cultivars released by our station continue to make cereal production possible in the rust area. This was particularly evident in 1986 when large areas of the prairies were exposed to the heaviest spore showers of rust in over 30 years. Susceptible winter wheat suffered severe losses, whereas the rust resistance of currently recommended cultivars prevented any significant damage to common or durum wheats.

The following is a brief summary of research carried out in 1986. Further information or reprints of this report or of the listed publications can be obtained by writing to individual scientists or to the Research Station, Research Branch, Agriculture Canada, 195 Dafoe Road, Winnipeg, Man. R3T 2M9; Tel. (204) 269-2100.

T.G. Atkinson
Director

BREEDING, GENETICS, AND CYTOGENETICS

Barley

Evaluation of the market potential of the two-row line TR212 was completed by the industry, and its malting and brewing characteristics were approved. TR212 possesses unique enzyme systems that significantly reduce malting time. It has been released under the name Ellice.

Over 5 years of testing, Ellice yielded equal to Harrington and more than Klages. It matures in about the same length of time as Harrington, which is 2–3 days earlier than Klages. Straw strength is superior to both these cultivars. Ellice has good test weight and kernel weight, and is slightly superior to Harrington and Klages in kernel plumpness. The resistance of Ellice to stem rust and most races of net blotch will permit it to be grown in the eastern prairies.

Emphasis in the breeding program was placed on a search for new sources of disease resistance and on incorporation of these into improved lines of two-row barley. PI382313 was screened from an Ethiopian collection as a promising new source of resistance to stem rust; C2-83-6-12, a six-row selection from North Dakota, was resistant to both spot and net blotch. Crosses were initiated to incorporate these resistances. As well, populations deriving resistance to loose smut from *Un*8, to net blotch from TR473, to spot blotch from the cultivar Bowman, and to scald from Wpg. 797-96-3, were advanced in the selection and testing program.

A historical series of barley lines was evaluated for all quality parameters to determine the source of some undesirable quality parameters, such as low peroxidase levels. However, no clear indication of the inheritance of low peroxidase level was obtained.

Common wheat

Roblin, a new Canada Western Red Spring (CWRS) wheat cultivar that combines higher protein content with good agronomic and disease characteristics, was registered in 1986. Based on 4 years of tests in Manitoba, Roblin is similar to Neepawa in yield but is approximately 1 day earlier maturing. It is more resistant to lodging and is shorter than other CWRS cultivars. Roblin has good resistance to stem rust, leaf rust, common root rot, and loose smut; it is susceptible to bunt. The wheat protein level of Roblin averages about 1% higher than Neepawa, thus increasing the probability of qualifying for the higher protein premiums.

Three new genes for leaf rust resistance are being transferred into Katepwa to provide broad-based resistance. Backcrossing for *Lr21* is complete, whereas the third and first backcrosses have been made for *Lr32* and *VPM*, respectively. Backcross lines of HY320 incorporating loose smut resistance were provided to other breeding programs for further evaluation and as parental material.

Two genes for leaf rust resistance were located as to chromosome: *Lr33* is on the long arm of chromosome 1B, closely linked to the centromere and with a previously located gene, *Lr26*; *Lr24* is on chromosome 7D. Lines possessing the *Lr34* gene for leaf rust resistance also have enhanced stem rust resistance. It is postulated that the enhanced stem rust resistance is due to *Lr34* being a "null" allele of the gene that suppresses stem rust resistance in Canthatch, or is closely linked to such an allele. In the backcrossing program to transfer the genes *Lr29* and *VPM* for leaf rust resistance into Thatcher, it was shown that their presence increased protein content but decreased mixing strength.

Single genes for resistance to all races of stem rust tested were transferred from each of the tetraploids *Triticum dicoccoides* (PGR6126) and *T. araraticum* (PGR6195) to hexaploid wheat. The gene *Sr33* was associated with an electrophoretic pattern missing four major gliadin bands found in Columbus. Quality screening tests indicated that *Sr33* is associated with weaker dough strength, which may be related to the missing gliadin bands.

As a possible alternative to the standard grinding time test for hardness, the hardness of individual kernels was evaluated by measuring the seed coat puncture resistance. Results indicated that a large amount of variation within a cultivar, partly accounted for by kernel size and shape, made the method unreliable. The standard test was modified by reducing the sample size from 5 g to 2 g. Although resulting in somewhat higher error, the modified test is useful for screening single plants.

Prairie spring wheat

In the recently initiated breeding program for Prairie Spring (triple-medium) wheats, supported by the Canada-Manitoba Agri-food Development Agreement, 17 new crosses were made and selection for desired agronomic and quality characteristics was carried out among 10 000 F_3 to F_7 lines. Investigations also revealed the possibility of selecting for more desirable kernel hardness within HY320.

Durum wheat

Fourteen new crosses were made and selection was carried out among 30 000 F_2 plants and 12 000 F_3 to F_6 lines. The program continues to emphasize good yield and shorter straw, including semidwarfs. However, semidwarf lines continue to have lower protein content and greater susceptibility to a number of diseases than lines of standard height. Sources of the semidwarf characteristic, other than the Norin-10 type, are being obtained to determine if they also exhibit these negative associations.

Sixty stable lines deriving post-harvest sprouting resistance from two hexaploid wheats, RL4137 and a white-seeded line, and the durum wheat line, D7075, were evaluated in rain simulator tests. Sprouting values ranged from 3.6 to 43% for experimental lines, with the highly dormant line RL4137 at 4.6%. The 30 best lines were evaluated further for agronomic and quality traits; several will serve as parental material for further crosses.

A source of high protein content is desired to retain protein level in high-yielding lines. Fifty-six lines, mainly originating from the U.S. Department of Agriculture and the University of Nebraska, were evaluated for protein and yield. Protein values were 14.2 and 14.9% for checks and experimental lines, respectively, with a range from 13.6 to 17.1% for the latter. However, the high protein experimental lines were low yielding, and none exceeded the best checks in protein per hectare. This may be due to poor adaptation of the material to Manitoba conditions.

Further modifications were made on the instrumentation and methodology of measuring viscoelastic properties of discs from semolina dough. The method correlated well to other measurements of gluten strength, such as sedimentation and mixograph tests. The relationship between viscoelastic properties of heat-denatured gluten and sedimentation values was also investigated. Correlations were highly significant and the test has potential as a quality screening technique.

Oats

The rust resistant oat cultivars, Dumont and Fidler, occupied 80% of the Manitoba oat area. The new cultivar, Riel, released in 1985, is not yet under commercial production. Three advanced lines, OT237, OT238, and OT239, have shown a good combination of yield, hull content, kernel size, and disease resistance. The best of these lines will be proposed for registration in 1987.

In the ongoing program to obtain and utilize new sources of rust resistance, 171 Canada *Avena* Collection accessions were screened to two test races of stem rust; nine accessions were resistant. In inheritance studies of previously identified resistance, one gene was involved in the resistance of five diploid accessions, and three genes were involved in the resistance of nine tetraploid accessions. The different ploidy level will make transfer of this resistance to cultivated oats difficult.

A study was conducted to determine the feasibility of incorporating tolerance to the herbicide, diclofop-methyl (Hoe-grass), into cultivated oats. This would allow use of this herbicide to control wild oats in oat crops. Screening of a diverse group of genotypes for tolerance to diclofop-methyl showed that the best source is the Australian cultivar, Savena 1. An inheritance study indicated that the tolerance of Savena 1 was not cytoplasmically controlled and likely due to two independent recessive genes. Tolerant F_5 lines possessing rust resistance and reasonable yield potential were obtained from this study, indicating that it should be possible to incorporate tolerance to diclofop-methyl into commercially acceptable oats.

CEREAL DISEASES

Pathology research is multifaceted and plays an integral part in the breeding of all cereal cultivars. Annual disease surveys are conducted to determine the prevalence of races of rusts and smuts and to determine the occurrence of viruses and of leaf spot diseases caused by fungi; new genes for resistance to various diseases are identified and transferred to desirable germ plasm; breeders' lines are evaluated for resistance to fungal parasites and viruses; basic studies are conducted on the biology, genetics, histochemistry, and ultrastructure of the pathogens; and long-term research is under way to explain the mechanism of host-parasite interactions and the molecular basis of resistance to cereal rusts.

Cereal rusts

The 1986 rust epidemic. Conditions were favorable for disease development on wheat in the Great Plains of North America in 1986. Both stem rust and leaf rust overwintered well in the southern United States and there was an abundance of susceptible cultivars to permit the rusts to develop. Some susceptible cultivars in Texas were killed by stem rust early in the year. The rusts may have overwintered as far north as the Dakotas and Montana, an event that is believed to be quite rare. These factors combined to create one of the earliest and heaviest buildups of rust inoculum in over 30 years. Leaf rust was first found in southern Manitoba on winter wheat on 5 June. The infections were well developed, suggesting that the initial infections had occurred about mid-May, 2–3 weeks earlier than usual. Stem rust was first observed in the 3rd week of June, again very early in the season. In most years, the rusts are first observed in the Red River Valley and gradually spread north and west. In 1986, both rusts appeared early over a wide area extending from eastern Manitoba west to Swift Current and Outlook, Saskatchewan. This heavy and widespread primary inoculum, the presence of 42 000 and 400 000 ha of susceptible winter wheat in Manitoba and Saskatchewan, respectively, and favorable weather conditions permitted the rusts to develop rapidly. In many winter wheat fields, the stem rust developed from trace infections to 80% or more in about 4 weeks. Rust development like this has not been seen in Canada since 1954. Fortunately, all of our recommended spring wheats, including the durums, are resistant to stem rust. Thus, even though the potential for disaster was high, there was no damage caused by stem rust, except to winter wheat and small areas of susceptible spring wheat, such as the soft white spring cultivar, Fielder, grown under contract. The leaf rust resistance of cultivars Columbus, Benito, Roblin, Sinton, Glenlea, and HY320 and of the durums continues to be good. Katepwa, which is less resistant to leaf rust than the previously listed cultivars, suffered some damage but developed less rust and performed better than expected in 1986. Norstar winter wheat was heavily infected by both rusts throughout Manitoba and Saskatchewan.

The oat rusts were first seen in late July, somewhat later than usual. Although weather conditions were ideal for the development of these rusts during most of the growing season, they did not cause any significant damage to the currently used oat cultivars.

Analysis of virulence. In 1985, 378 field and nursery isolates of stem rust were characterized with 16 differential lines of wheat. Fifteen virulence combinations, including two new ones, were identified. Race *C53*, dominant since 1977, comprised 92% of all isolates countrywide. The new races are not a threat to commercial spring wheats.

Wheat leaf rust races were identified with 17 backcross lines of wheat, each with a single gene for resistance. Lines with genes *Lr19*, *Lr21*, *Lr25*, *Lr26*, and *Lr29* were resistant to all isolates tested. Seven isolates from Manitoba and Saskatchewan were virulent on seedlings of cultivar Columbus and plants with gene *Lr16*, and on adult plants of cultivar Manitou (*Lr13*), but adult plants of cultivar Columbus (*Lr16* and *Lr13*) were resistant to these isolates. Eleven isolates from Manitoba and Saskatchewan were virulent on adult plants of cultivar Benito (*Lr1*, *Lr2a*, *Lr12*, and *Lr13*). A total of 45 virulence combinations were identified.

There were no significant new physiological races of crown rust of oats and oat stem rust in western Canada. In eastern Canada, two new oat rust races were identified: a crown rust isolate with virulence on the recently released oat cultivar Woodstock and a stem rust isolate lacking virulence on the resistant genotypes currently used in oat breeding.

Identification and use of sources of resistance. Efforts were continued to transfer resistance genes *Sr2*, *Sr22*, *Sr26*, and *Sr33* into spring wheat cultivars Columbus and/or Benito. Winter wheat (cultivar Northstar) backcross lines were produced containing resistance genes *Sr31* and *Lr26*, as well as lines with genes *Sr24* and *Lr24*. To support the oat breeding program, F_2 families of an *Avena sterilis* accession were tested for segregation for resistance to stem rust in both seedling and adult plant stages. All progeny were susceptible as seedlings but segregated for a single dominant resistance factor as adult plants, confirming the presence of a new and potentially useful source of oat stem rust resistance in this accession. Similar work with two new Iberian wild oat accessions indicated that they contain a useful gene for resistance to oat crown rust.

Molecular biology of cereal rust diseases. Previous work had shown that intercellular washing fluid from stem rust-affected wheat leaves contains fungal proteins and that some of these proteins differ, depending on the race with which the leaves were inoculated. That these proteins are race-associated was confirmed by comparing washing fluids from leaves that had been inoculated with one of several isolates of one race; the protein patterns were indistinguishable between samples of these isolates. The existence of race-associated proteins makes it possible to develop an immunochemical procedure for race identification that may be simpler and faster than that based on the use of differential cultivars and lines of wheat. Efforts were made to explore conditions for color transformation of gray mutants of the stem rust fungus. A system such as this would allow quick and efficient screening of rust colonies for possible transformants and may be useful as a model for genetic transformation involving avirulence genes. In work preliminary to the isolation of rust resistance genes from cereals, several thousand barley stripe mosaic virus-infected barley seedlings were screened for transposon induced mutations but none were found.

Chemotaxonomy. Two-dimensional electrophoresis was used to compare proteins extracted from spores of several cereal stem rusts to explore the taxonomic relationships of these pathogens. Nineteen polypeptides varied among nine races of rye stem rust. This difference was greater than the interspecific variation between rye and wheat stem rusts that had 270 polypeptides in common but differed by 17. Rye and oat stem rusts differed by 92. The close relationship between rye and wheat stem rusts was further supported by the almost identical polypeptide pattern of a wheat stem rust race and that of an F_1 hybrid between rye and wheat stem rust and of its parents.

Smuts

Wheat and oats. Field surveys were conducted to determine the incidence and severity of smut infections on the eastern prairies. In cultivars of hard red spring wheat, 16% of the fields showed some infection, with a mean of 0.01% and a maximum of 0.5%; in the semidwarf wheats, 78% of the fields were infected, with a mean of 1.2% and a maximum of 7%. In durum wheat, the percentages were 30, 0.08, and 1%, respectively; in oats, 33, 0.2, and 3%. Since smut found anywhere may constitute a potential hazard for Canadian wheat production, field collections of wheat from China, Ireland, and Italy were analyzed for smut races they contained. One collection from Italy was a new race; all others were known races. None of the races threaten wheat cultivars currently grown commercially in Canada.

Barley. Surveys in Manitoba and Saskatchewan detected smut in 79% of the fields, with an average of 0.7% loose, 0.1% false loose, and 0.2% covered smut. Due to weather conditions, susceptible varieties, and the prevalence of a virulent race, the incidence of smut in Manitoba was the highest since 1964. The *Un8* allele for loose smut resistance was found to condition necrosis of embryos of infected barley, a type of reaction that has not previously been reported.

Foliage mycoses caused by fungi other than rusts

A survey of 66 wheat fields was done in south central Manitoba to determine the presence and severity of *Fusarium* head blight. Head blight was identified as a field disease in the Red River Valley, at levels up to 20% head infection. The highest levels occurred in semidwarf and durum wheats, whereas hard red spring wheats had only trace infections. This disease now appears to be endemic in southern Manitoba. Barley accessions with known resistance to *Pyrenophora teres* were tested for their reaction to biotypes of the pathogen representing the virulence currently identified in western Canada. Five lines with moderate to good resistance to all isolates were identified. Four of these have not been used in Canadian barley breeding programs and may be useful in the future. Adult plant resistance to net blotch was identified in several Canadian barleys and was found to be isolate-specific. Such barleys may be suitable for production in regions where net blotch occurs, but where it is not an early season disease.

Viruses

Surveys conducted in 1986 confirmed and extended the findings of two new cereal virus or virus-like diseases first observed in 1985. One of these concerns a new variant of brome mosaic virus (BMV) and represents the first isolation of BMV in Canada. The Manitoba BMV isolates induce atypical local-lesion symptoms in several broad-leaf indicator hosts and induce the formation of an additional species of double-stranded RNA as an intermediate product of infection in infected cereal hosts. The other disease, "flame chlorosis" of barley, also has been partially characterized. Its transmission via soil was confirmed, and electron microscopy has demonstrated an unusual cytopathology induced by the infectious agent.

STORED PRODUCTS PROTECTION

Research on the biology and control of pests in stored cereals and oilseeds emphasizes the interaction of insects, mites, and microorganisms in a dynamic storage environment. The program includes studies of management of grain storage systems; factors that limit long-term storage; survey, prediction, and control of microflora and mycotoxins in stored cereals and oilseeds; identification and quantification of insect and mite populations in stored products; influence of attractants and feeding stimuli on insect behavior; and the control of insects and mites by environmental, physical, and chemical means.

Storage ecology

The results of the 6th year of a 10-year on-farm cereal storage study at Argyle, Man., to determine the efficacy of a 2.2-kW, two-duct ventilation system showed that wheat and barley harvested in August 1985 could be stored with minimal quality loss. Health of pigs was unaffected when the grain was used as feed. Potential for mycotoxin production, however, was demonstrated when two damp samples of barley from the floor of a 544-t bin were found to contain the mycotoxins citrinin (0.8–5.2 ppm), ochratoxin A (0.6–2.2 ppm), and sterigmatocystin. The farmer was advised to discard the damp grain to avoid animal sickness.

Two wooden granaries near Winnipeg were each filled with 14 t of dry wheat, and the impact of a contact insecticide on one ecosystem was determined monthly for 27 months. The wheat in one granary was treated with 8 ppm malathion prior to storage, and the wheat in the other granary was untreated. The malathion offered effective insect control for about 10 months when residue levels had declined 50%. There were significantly more arthropods and seed infection by *Penicillium* in the control granary than in the treated granary. The presence of a contact insecticide in a stored-wheat ecosystem had significant effects on the faunal community and definite but less conspicuous effects on the microfloral community.

Microflora and mycotoxins

Ochratoxin A formed at maximum levels of 0.95 and 0.05 ppm in six-row and two-row barley at 19% moisture during a 14-month storage test in a typical farm granary. Other parameters indicating microfloral activity also were significantly higher in the six-row barley than in the two-row barley: heating, moisture increase, oxygen consumption, CO_2 and free fatty acid evolution, and propagule count.

Biology

An energy budget of all life stages of the almond moth, *Ephestia cautella* (Walker), was developed for insects that fed on single wheat kernels at 30°C and 80% relative humidity (RH). Larvae consumed 33.9 mg (605 J) of wheat during development. A wheat kernel contained 17.9 J/mg or 750 J/kernel. Cumulative energy loss from respiration was 176 J in 35 days. The efficiencies of energy use were determined and the potential impact of this pest on stored wheat considered. These data will be used to develop computer simulation models to predict and manage future infestations of this moth.

Trapping of insects in small bins of stored wheat was carried out for two seasons in an unheated building in Winnipeg. Tubular brass-screen traps with six vertical sections were placed in nine 218-kg bulks of wheat. Adults of the red flour beetle *Tribolium castaneum* (Herbst), and the rusty grain beetle, *Cryptolestes ferrugineus* (Stephens), were placed in the bins at 1, 5, and 10 insects of each species per kilogram of wheat. At temperatures as low as 3°C, both insects were captured in the traps. At temperatures greater than 17°C, two to three times more insects were caught in traps containing wheat germ than without. Standard grain probe samples were not reliable for detecting or quantifying insect populations.

Five diets (unenriched wheat flour plus brewers' yeast, enriched commercial wheat flour, unenriched wheat flour, ground brown rice, or ground wheat) were given to the confused flour beetle, *Tribolium confusum* Jacquelin du Val. Unenriched wheat flour plus brewers' yeast resulted in most rapid development and greatest pupal weights; this diet was slightly superior to ground wheat. Flour enriched with three B-group vitamins did not promote larval development. Larvae held at 10 per gram of food developed significantly more slowly than those held at one per gram of food.

Insect detection traps baited with synthetic aggregation pheromones of *C. ferrugineus* were inserted into grain stored in primary elevator annex bins and in farm bins. In elevator annex bins, the number of beetles found after 1 week ranged from 0 to 7300. More beetles were found at 30–60 cm depth than at 150–250 cm depth, and there was a positive correlation between numbers of insects and amount of pheromone released. In farm bins, the pheromone-baited traps were not significantly more effective than unbaited traps.

Population fluctuations of adults of *C. ferrugineus* were monitored in wheat stored in a steel granary, using insect detection traps placed 35 cm below the surface at the centre of the granary for 2 years. Peak populations occurred from the beginning of September to the 3rd week of October. No beetles were detected from mid November until June. No insects were captured below 4°C, and 65% of adults taken from grain at −7°C in February became active in the laboratory.

Two species of rapeseed (*Brassica campestris* L. cv. Candle; *B. napus* L. cv. Regent) were treated with malathion or pirimiphos-methyl and stored at 50 or 70% RH and 10, 20, or 30°C for up to 32 weeks. Residues of the insecticides were monitored regularly by gas chromatography and bioassay with the grain mite, *Acarus siro* L., and with *T. castaneum*. Malathion levels decreased more slowly on Candle than on Regent seed; pirimiphos-methyl persisted on both cultivars. Arthropod mortality decreased rapidly, indicating insecticide levels diminished mainly at the seed surface; however, residues in the seed did not change appreciably.

CROP PROTECTION

Research on insect pests of oilseed, cereal, vegetable, and special crops emphasizes aspects of their biology and control leading toward better prediction of infestations, crop protection, and the reduction of pest populations. The program includes the development of pest-monitoring techniques, development and field testing of chemical and biological insecticides, and investigation of methods of reducing pest abundance, using natural enemies, plant resistance, and other nonchemical approaches. These programs are supported by research on sampling techniques, survival, development, phenology, host selection, induction and termination of diapause, overwintering strategies, reproductive biology, and biochemical bases of neurotransmission.

Monitoring and prediction

The sampling of eggs of the cabbage root maggot, *Delia radicum* L., provided a better basis for decisions on the need for and timing of insecticidal treatment of rutabaga in Manitoba than did the sampling of adults.

A sequential sampling plan was developed for the pea aphid, *Acyrthosiphon pisum* (Harris), in field peas to provide producers with a rapid and accurate method for determining the need for insecticidal control. The plan requires the examination of a minimum of 20 plant tips to determine whether the population exceeds the economic threshold of two to three aphids per tip. The minimum number of samples was all that was needed to reach a decision in 24 of the 25 fields in which the method was tested.

The sugarbeet root maggot, *Tetanops myopaeformis* (Röder), is a pest of economic concern to sugar beet growers in the light sandy soil areas of southern Manitoba. For the first time, this pest was found near Winnipeg and Portage la Prairie. These locations are up to 100 km north of the main maggot area, and the infestations occurred on heavy clay loam soils.

Sex attractant traps containing lures for three cutworms (*Euxoa messoria* (Harris), *E. ochrogaster* (Guenee), or *Feltia jaculifera* (Guenée)) are effective in capturing males, but the number of males captured does not provide an accurate prediction of larval numbers in the same fields the following year. These cutworms, therefore, are not suitable candidates for field-specific prediction of larval abundance from sex attractant trap captures.

As part of a project funded under the Canada–Manitoba Economic and Regional Development Agreement, the distribution and damage caused by selected insect pests of field crops in Manitoba was determined. Damage caused by *Lygus* bugs and by the cabbage root maggot was found in canola fields throughout the province. Except in a few fields, the damage caused by *Lygus* bugs was less than 10%. Damage to canola roots by the cabbage root maggot varied from 2.5 to 73.8% among fields, but the level of damage does not seem to be high enough to affect yields. The European corn borer, *Ostrinia nubilalis* (Hubner), was found in all fields in the main corn-growing areas, with some fields experiencing economic damage. The distribution of the sunflower midge, *Contarinia schultzi* Gagné, was again found to be confined to the Red River Valley. Fields close to the Red River were more severely infested than those away from the river. In individual fields, the severity of damage decreased with distance from the edge. The density of cutworm larvae in minimum-tillage fields was slightly higher than in conventional-tillage fields but the differences were not significant, because cutworm populations were low during 1986.

Damage assessment

It was shown that sunflower yield loss caused by the sunflower midge can be estimated, using a system of classifying damaged heads on the basis of their shape and size. This system will enable sunflower-growing areas to be rated on the basis of expected yield loss.

In canola, pod damage caused by larvae of the bertha armyworm has been shown to be a reliable guide for control decisions for this insect. Significant loss of yield and quality can be expected if 20% of the pods are damaged, and insecticides should then be applied as quickly as possible.

Biological control

Collections of parasitized pea aphids from alfalfa fields in the Red River Valley confirmed the establishment of the parasitoid, *Aphidius smithi* Sharma & Subba Rao, from releases made in 1984 and 1985. *A. smithi* has overwintered and dispersed up to 15 km from the original release sites. An additional 26 087 parasitoid adults were released in 1986.

In 1986, 559 male and 2459 female adults of the parasitic tachinid fly, *Ernestia consobrina* (Mg.), were released in the Swan River Valley against bertha armyworm larvae. No progeny of the 1985 release were recovered from larval collections. Laboratory experiments showed that the overwintering stage of *E. consobrina* is coldhardy and capable of surviving under Manitoba conditions.

The breeders' lines of canola entered in the Canola–Rapeseed Coop tests were assessed for susceptibility to damage by flea beetles, *Phyllotreta* spp., but none were found to be less susceptible than the standard cultivars Westar and Tobin. Single plant selections were tested for seedling resistance to flea beetles; the survival of the progeny of one plant was twice that of Westar.

Insecticides

Laboratory evaluation of 79 strains of *Bacillus thuringiensis* Berl., for toxicity to larvae of the bertha armyworm identified nine strains that were significantly more toxic than the standard commercial strain. No evidence of synergism was found in mixtures of the standard *Bt* formulation with boric acid, ethylenediaminetetraacetic acid (EDTA) sodium salt, magnesium chloride, calcium sulfate, or sorbic acid.

Evaluation of a granular formulation of phorate at 280 g/ha indicated it was not as effective as carbofuran at 280 g/ha for control of flea beetles on canola. However, at a rate of 560 g/ha this insecticide was as effective as carbofuran at 280 g/ha.

Foliar sprays of five synthetic pyrethroids were effective (98–100% kill, 72 h after application) for control of the Colorado potato beetle, *Leptinotarsa decemlineata* (Say), on potato. Only one spray of each insecticide was applied in mid-July. Since 1979, it has been shown that one application of an effective insecticide is all that is required if the application is delayed until after most eggs hatch.

Biology and physiology

Comparison of populations of pea aphids collected from five sites in central North America (Kansas, Minnesota, North Dakota, Manitoba, and Saskatchewan) showed that there was no evidence that temperature-dependent traits (developmental rate and developmental threshold) were adapted to local temperatures.

The characteristics of the calling behavior of female bertha armyworm moths were studied as a background to improving and understanding the results of monitoring systems, using sex attractant traps. Virgin females first began calling and mating when the ovaries contained the first mature eggs, which occurred 2 or 3 nights after emergence when kept at 20°C and a photoperiod of 16 h light and 8 h darkness. The first egg laying occurred 3 or 4 nights after emergence, and mated females called again 2 days after the first mating. Once calling was resumed after mating, the females laid eggs and called nightly, with egg laying occurring during the first 5–6 h of the night and calling during the last 2–3 h. The time of initiation of daily calling was advanced by about 3.75 h and the length of the calling period increased by about 4 h during the first 7 days after emergence. The length of the period of darkness delayed the onset of calling if the night was 12–18 h long. However, there was very little effect when the nights were 6 to 10 h long; this period spans the duration of night during the flight period of the bertha armyworm in western Canada.

Temperature affected four aspects of calling behavior of female bertha armyworm moths: age at first calling, diel periodicity of calling, length of the daily calling period, and percentage of females calling. Calling occurred at all temperatures from 5 to 35°C, but an evaluation of the data for these four aspects of calling behavior suggests that the optimum temperature range for calling is at least 10–25°C. The upper limit is near 35°C and the threshold less than 5°C. Mean daily minimum air temperatures are between 6 and 14°C during the flight period of the bertha armyworm in western Canada. Nighttime temperatures, therefore, normally are suitable for calling of the bertha armyworm.

Spermatocyst elongation in male bertha armyworm follows and is correlated with increasing concentrations of 20-hydroxyecdysone in the developing pupae. Experimental suppression of this chemical, using ecdysteroid hormone, did not affect spermatogenesis, indicating that the high levels of ecdysteroids that occur in the developing pupae are not required for spermatogenesis and that ecdysteroid hormones are not useful for sterilizing male pupae. Treatment of diapausing pupae with 3-isobutyl-1-methylxanthine or cyclic GMP promptly terminated their diapause and promoted development. Treatments with other methylxanthines such as theophylline, 8-phenyltheophylline, caffeine, or papaverine had little or no effect. Treatment of diapausing or post-diapause pupae with dibutyryl cyclic AMP or 8-(4-chlorophenylthio) cyclic AMP either kept the pupae in diapause or blocked their development. This research established that pupal diapause is under dual control by cyclic nucleotides, with cyclic AMP acting to maintain diapause and cyclic GMP acting to terminate it.

A morphologically unique corpus allatum was discovered in the head of moths of the bertha armyworm. The morphology, ultrastructure, and taxonomic distribution of the endocrine gland in Lepidoptera were studied. The extraordinary gland was restricted in its distribution to adult noctuids of the subfamily Hadeninae. Ultrastructural studies of the gland in aging males and females indicated that isolated single cells of the corpora allata may be an ideal system for investigating the regulation of juvenile hormone biosynthesis.

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Research Station, Melfort Saskatchewan

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Vacant	Program Leader
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N. Malik, B.Sc., M.Sc., Ph.D.	Weed control
Z. Mir, B.Sc., M.Sc., Ph.D.	Beef cow–calf nutrition, forage utilization
T. Yeager, B.Eng.	Forage harvesting and handling

Departure

W. Conrad, B.Sc.
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VISITING SCIENTIST

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INTRODUCTION

The Melfort Research Station serves producers in the Black and Gray wooded soils in the Aspen Parkbelt of Saskatchewan, an area containing at least 10% of Canada's improved agricultural land. The area has a mixed farming economy, with emphasis on wheat, barley, canola, forage crops, and beef cattle. Major agronomic problems are soil degradation, weeds, insects and diseases of crops, and a short and variable growing season. Researchers were involved in some 34 individual projects carried out in 1986, under two programs – Beef-Forage Production Systems and Cereal, Oilseed, and Special Crop Production.

For more complete information, readers may contact the Research Station, Research Branch, Agriculture Canada, P.O. Box 1240, Melfort, Sask. S0E 1A0; Tel. (306) 752-2776.

S.E. Beacom
Director

CEREAL, OILSEED, AND SPECIAL CROP PRODUCTION

Effect of seeding method and fertilizer on wheat yields. In a 7-year study, zero till seeding of wheat into wheat stubble with a narrow shovel hoe press drill and a triple disc press drill yielded 1436 and 1456 kg/ha, respectively, whereas with minimum till seeding the narrow shovel hoe press drill and a discer with packer yielded 2043 and 2111 kg/ha, respectively, averaging four levels of nitrogen. Averaging seeding methods, applications of N at 0, 56, 112, and 168 kg/ha in spring yielded 1519, 1774, 1871, and 1882 kg/ha, respectively. Seeding and nitrogen treatments were repeated on the same plots each year. Soil temperatures were 1–3 degrees higher under minimum till seeding than under zero till seeding for several weeks after seeding.

Weed control. In weed control studies in 1985 and 1986, new herbicides DPX 6202 applied at 0.15 kg/ha, and DPX 6202-31 applied at 0.1 and 0.5 kg/ha plus Canplus at 0.5% suppressed quackgrass in canola and flax. Sethoxydim at 0.8 and BAS 517 at 0.4 kg/ha also suppressed the quackgrass in flax. The treatments minimized the quackgrass competition without damaging the crops. In similar tests HY 320 (medium quality) and Katepwa (hard red spring) wheat cultivars showed similar tolerance to broadleaf and grassy weed herbicide treatments.

Cereal harvesting. HY 320 and Katepwa wheat swathed at about 20 to 30% kernel moisture content produced maximum yield and quality in 1985 and 1986. Earlier swathing at higher moisture resulted in earlier combining with less weathering in the field. HY 320 yielded approximately 145% of Katepwa.

Crop residue management practices. Seedbed preparation is important for incorporating crop residues, herbicides, and fertilizers into the soil in the fall. Four fall tillage implements (plow, heavy duty cultivator, one-way disc, and double disc), no tillage (with straw chopped), and spring burn treatments were compared in a 25-year continuous wheat rotation with N and P fertilizers as subplot treatments. There was a significant fertilizer response (0.63 t/ha yield increase), and a fertilizer by tillage interaction, but there was no significant effect of tillage method on wheat yields. Spring burning gave the highest yield (2073 kg/ha^{-1}) and the plow treatment the lowest yield (1963 kg/ha^{-1}). Plowing caused a loss of organic C and N. All tillage treatments increased the erosive fraction of the soil (i.e., particles < 0.83 mm). Application of N at 90 kg/ha and P at 20 kg/ha decreased the erosive fraction. Chopped straw with no fall tillage was the best treatment. If fall tillage is necessary, any implement except the plow would be suitable.

Improved system for data collection. An automated sampling and weighing system was developed for a Hege plot combine. A pneumatic conveyor delivers the grain from the grain pan to the scale and the weight is recorded electronically into a microcomputer. The labor requirement in harvesting and data entry was reduced by 75% with this system.

Pulses in rotation. In a 5-year experiment, barley yields following pulse crops (fababeans, field peas, lentils) averaged 21% greater than following barley. Although differences among pulse residues were small, higher barley yields occurred following fababeans and field peas than following lentils. Pulse residues also affected barley quality, increasing kernel weight and percentage of plump kernels by 5% and protein content by 0.6 percentage points. The response to nitrogen was similar on pulse and barley residues. Maximum yield was obtained with less nitrogen on pulse than barley residues, but nitrogen fertilizer at levels up to 200 kg/ha was not able to bring the yield on barley residue up to the maximum yield attained on pulse residues. In the 2nd year following pulses, the dry matter yield, grain yield, and nitrogen uptake of wheat was 15% higher than in the continuous cereal sequence.

BEEF-FORAGE PRODUCTION SYSTEMS

Forage crops

Weed control. Dry matter yield of timothy, Altai wild ryegrass, meadow bromegrass, and smooth bromegrass increased in response to applications of chlorsulfuron, metsulfuron methyl, and dichlofop-methyl plus bromoxynil at the seedling stage in the preceding year. Sethoxydim tested at 0.15–0.25 kg/ha severely injured the forage grasses in the establishment year and reduced yields in the following year. Seedling alfalfa, red clover, and sweetclover were tolerant to AC 263 499, ethalfluralin, and EPTC. Chlorsulfuron and metsulfuron-methyl applied at 12 g/ha to loam, silty clay loam, and clay soils in northeastern Saskatchewan injured alfalfa and killed red clover and sweetclover seeded after cereals the following year. Sweetclover underseeded with Polish rapeseed resulted in the highest yield when the two crops were sown at 10 and 5 kg/ha, respectively.

Effect of drought on leaf senescence and forage quality. Plant growth on the prairies occurs mainly in spring. Summer pasture consists of quiescent, drought-stressed vegetation. A 2-year study was undertaken to evaluate the effect of drought on quality of the commonly grown grasses, crested wheatgrass (CWg), smooth bromegrass (Br), and Altai wildrye (AWr). Drought increased the rate of leaf senescence most in CWg and least in AWr, and more in floral than nonfloral tillers. Drought increased the rate of seasonal decline of N and P most in CWg and least in AWr, probably due to the mobilization of nutrients out of senescent tissue. Drought reduced the rate of decline of in vitro digestibility, despite increased senescence, by slowing increase in lignin, acid detergent fiber, and cellulose. Summer pasture may be improved by introducing cultivars with a high proportion of nonflowering tillers.

Fertilizing pasture. The cost of applying N at 90 kg/ha plus P at 45 kg/ha to Gray wooded roughland pastures every other year has been met or exceeded by the value of increased calf weight gains. From 1977 to 1984, 1 ha of rotationally grazed fertilized pasture produced an average weight gain of 43.6 kg for cows and 88 kg for calves, whereas 1 ha of continuously grazed unfertilized pasture produced an average weight gain of 24.5 kg for cows and 57.9 kg for calves. In 1985, 1 ha of fertilized pasture produced an average weight gain of 103.5 kg and provided 89 calf-grazing days, whereas unfertilized pastures produced an average weight gain of 54.4 kg and 45.1 calf-grazing days. From 1974 to 1985, dry matter (DM) production from paddocks fertilized in the preceding fall averaged 2982 kg/ha. In the next grazing season, with no additional fertilizer, DM production averaged 1660 kg/ha, whereas in unfertilized pastures DM production averaged 1143 kg/ha. In forage stands that were reseeded and fertilized in 1979 and fertilized in the spring of 1981, 1983, and 1985, DM production averaged 4024 kg/ha compared to 1121 kg/ha for control pastures.

Forage handling and preservation

Breaking up large round bales. The effectiveness of using portable power tools including a chain saw, skillsaw, carbide cut-off saw, Wellsaw, and band saw to slice large round hay bales was evaluated. A chain saw with an 89-cm^3 engine and a 0.9-m blade sliced the round bale through the centre readily. Using a 99-cm^3 engine and a 1.8-m blade, two operators could slice through a round bale in a single stroke. A large, twin-bladed bandsaw (two vertical and two horizontal cuts) fitted onto a bale mover was designed to slice round bales into nine sections to simplify feeding and processing in some situations.

Automated bale sampling unit. A power forage sampler for round bales was developed. The machine cores and ejects a sample in 0.5 min, with little physical effort and is very safe to operate.

Round bale silage bagging system. Removing the air in round bale silage tubes with an industrial type vacuum cleaner was effective in reducing the temperature rise during fermentation and in eliminating mold. The lower temperature of the silage tube made it less attractive to cats, who tend to puncture the plastic with their claws as they seek a warm place to lie down.

Preserving high-moisture hay with anhydrous ammonia. A 2-year experiment has shown that 2% ammonia (wt/wt, in plastic covered stacks), at a cost of $13.50/t of DM, was adequate to preserve large round bales of alfalfa or brome–alfalfa hay harvested at 30% moisture. There was adequate distribution and retention of the injected ammonia. The keeping quality of the hay was excellent. There was no aerobic fermentation or mold. The dry matter intake and performance of growing steers were similar to those fed field-dried hay. The major benefit of treating high-moisture hays with anhydrous ammonia, when compared with baling at 18–20% moisture, is that it reduces field losses and other weather-related damages. Two incidents of ammonia toxicity were encountered; however, removal of ammoniated hay for 48 h eliminated the problem.

Ruminant nutrition

Additives in finishing rations. In a test involving 209 crossbred cattle (average initial weight 388 kg), returns to labor increased from $15 to $35 per head by using the feed additives aureomycin (Aurofac 50) (350 mg per head daily), monensin (Rumensin) (11 and 33 g/t of DM prior to and following 28 days on feed, respectively), or lasalocid (Bovatec) (33 g/t of DM). Cattle were fed a crested wheatgrass ration for 56 days and gradually changed to a barley-based ration. Results for the control, aureomycin, rumensin, and lasalocid treatments, respectively, were as follows: average daily gain (kilograms) 1.27, 1.37, 1.36, and 1.36; feed-to-gain ratio 9.9, 9.4, 8.8, and 9.1; backfat thickness (millimetres) 7.4, 7.3, 7.4, and 7.7; finished weight (kilograms) 520, 538, 531, and 524; percentage of grades A_1 and A_2, 96, 100, 100, and 93; dressing percentage 52.0, 53.1, 52.2, and 52.1; and returns to labor $26, $61, $48, and $41.

Milk replacer for lambs. Weight gains and intestinal absorptive capacities of lambs fed milk replacer or dam's milk, with or without access to creep feed were determined in a 5-week trial with 32 week-old lambs. Dam-fed lambs gained more weight than lambs receiving milk replacer (440 and 338 versus 276 and 244 g/day). Lambs fed milk replacer and having access to creep feed gained the least (157 g/day) during the first 3 weeks of the experiment but showed average weight gain by the end of the trial. Milk replacer-fed lambs appeared to have better nutrient absorption capacities than those fed dam's milk, even though they had reduced villus height and lactase activity in the duodenum.

PUBLICATIONS

Research

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A.I. Hsiao, B.Sc., M.Sc., Ph.D.	Weed seed dormancy, wild oat herbicides
L. Hume, B.Sc., Ph.D.	Crop losses, ecology
J.H. Hunter, B.S.A., Ph.D.	Control – annual crops
A.G. Thomas, B.Sc., M.Sc., Ph.D.	Surveys, ecology
R.F. Wise	Computer Programmer

Herbicide Behavior in the Environment

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A.J. Cessna, B.A., Ph.D.	Residues, plants
D.A. Pchajek, B.S.A., M.Sc.	Application technology (Economic Regional Development Agreement)
A.E. Smith, B.Sc., Ph.D., D.Sc., F.C.I.C.	Residues, metabolism, soil

Experimental Farm, Indian Head, Sask.

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G.P. Lafond, B.A., B.Sc.(Hon.), M.Sc., Ph.D.	Agronomy, cereal crops

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VISITING SCIENTIST

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Graduate students

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[3] Commenced work 2 September 1986.

[4] On educational leave for Ph.D. training from Research Program Service, Ottawa, since September 1983.

INTRODUCTION

This report covers the results of work completed in 1986 at the Regina Research Station and the Indian Head Experimental Farm. The program of the Regina Research Station focuses on the biology and control of weeds in cultivated crops and pastures. The extensive use of herbicides in prairie agriculture has created a demand for scientific information on efficacy, crop tolerance, persistence in soil, and movement away from the intended target. In recent years, our program has also examined exposure hazards to herbicide sprayer operators and successfully developed means to minimize hazards in handling herbicides. New technology is being developed for the use of plant pathogens and insects for the control of weed species as an alternative to control with herbicides. A project on the technology of herbicide application is funded under the Economic Regional Development Agreement (ERDA).

In addition to the weed research program, the station participates in the South Saskatchewan wheat breeding program. New cultivars of cereals, oilseeds, forages, and pulse crops are evaluated for adaptability to southeastern Saskatchewan. Agronomic experiments develop new information for soil and crop management.

At Indian Head, research programs include special crop and cereal agronomy. The values of extended crop rotations and reduced or conservation tillage are being investigated in several projects, including a cooperative project funded by the Economic Regional Development Agreement and Hoechst Canada Inc.

The Seed Increase Unit is responsible for increase of seed of new crop varieties developed by Agriculture Canada for distribution to the seed industry and for a winter plant breeding nursery in California.

More detailed information can be obtained from publications listed at the end of this report or from individual scientists. Enquiries may be directed to the Research Station, Research Branch, Agriculture Canada, 5000 Wascana Pkwy., P.O. Box 440, Regina, Sask., S4P 3A2; Tel. (306) 585-0255.

T.F. Townley-Smith
Director

BIOLOGICAL CONTROL

Diffuse and spotted knapweed

Biological control is starting to have an impact on diffuse and spotted knapweed, two weeds of eastern European origin that are the main threat to the dry grasslands of western Canada. Each insect species established reduces knapweed seed production at the release site by approximately 50%. It is estimated that a total of six insect species will be needed to achieve control of each knapweed; fortunately, several control agents attack both weeds. The program is being done as a cooperative project between the Reseach Branch, the B.C. Ministry of Forests, and the B.C. Ministry of Agriculture and Fisheries.

The two seed-head flies *Urophora affinis* and *U. quadrifasciata* are established on most knapweed infestations in British Columbia. Seed production at Chase, B.C., has declined from approximately 36 000/m^2 to 1500/m^2. The diffuse knapweed root beetle *Sphenoptera jugoslavica* attacks about half of the rosettes at White Lake, B.C. Seed production at the site with the two flies and the beetles has declined from around 26 000/m^2 to 1900/m^2, with production still decreasing. The beetle requires hot, dry conditions in July and August for successful breeding. In 1986, about 16 000 beetles were distributed through the suitable region.

The seed-head moth *Metzneria paucipunctella*, which attacks up to 75% of the spotted knapweed seed heads in the dry region near Trail, B.C., destroys about five more seeds per head than the flies alone. The root-feeding moth *Agapeta zoegana* survived well on spotted knapweed at Kamloops, B.C. Several secondary releases were made. The root-feeding moth *Pelochrista medullana*, a species that in Europe is found in dry sites, increased well in a field cage at Kamloops in 1986. The root-feeding moth *Pterolonche inspersa*, a species that in Europe is found in hot, dry sites, was approved for release in 1986.

Host specificity testing is under way for a root-feeding weevil *Cyphocleonus achates*, a species that attacks large plants; a diffuse knapweed seed-eating fly, *Terellia virens*; and a spotted knapweed seed-eating fly, *Chaetorellia* sp.

The knapweed rust *Puccinia jaceae* attacked safflower in field tests in Europe; therefore it is unsuitable for introduction as a biocontrol agent to North America. However, the two knapweed rusts known as *P. jaceae* and *C. centaureae* appear to be a complex of species that cannot be distinguished morphologically but differ in up to a third of their polypeptides. Thus, the rusts reported from other subgenera of knapweeds are probably different species.

Round-leaved mallow

An endemic fungus *Colletotrichum gloeosporioides*, causing anthracnose of round-leaved mallow, has shown good potential as a bioherbicide. It is specific to *Malva* spp., and a few other closely related species in the Malvaceae family. Field tests conducted in Saskatchewan and Manitoba gave 100% control of round-leaved mallow when a spore suspension of *Colletotrichum gloeosporioides* was sprayed in plots of wheat, lentil, and flax. This fungus has been turned over to a private company, Philom Bios, Saskatoon, for commercialization. Patent applications have been filed in the United States (September 1985), in Canada (September 1986), and in Europe (September 1986) in the name of Agriculture Canada.

Taxonomy studies of round-leaved mallow conducted from 35 different sites showed that two main biotypes occur in Saskatchewan and Manitoba with morphological and ecological differences.

From competition studies in heavily infested round-leaved mallow plots, yields were reduced by 56% in lentil and 23% in wheat. Control of round-leaved mallow, using *Colletotrichum gloeosporioides* as a bioherbicide applied at the 4–6 leaf stage, resulted in substantial yield increases (2.3 times in lentil and 1.7 times in wheat) under very heavy infestations.

Colletotrichum gloeosporioides spores do not survive in or on the soil. Only a few viable spores were found 4 days after spraying the soil with 100 times normal field rate. However, the fungus survived in infected tissue when on the soil surface but degraded rapidly once buried. After overwintering, *Colletotrichum gloeosporioides* only survived from surface tissue to levels similar to what occurs naturally.

Canada thistle

The Canada thistle stem-gall fly, *Urophora cardui*, was released in Canada from 1974 to 1975 with stock collected in the Rhine Valley of France and Germany, but the colonies died out in western Canada. After it had been found that colonies which thrived in New Brunswick had become more winter-hardy than the original stock, and that wind-protected sites were most favorable, the strain from New Brunswick was released in Saskatchewan in 1984. This colony has managed to survive. In 1986 a strain from Helsinki, Finland, was released, which is even more winter-hardy (winter mortality only about 10% as compared to 20% of the New Brunswick strain). With the cool spring and early summer temperatures prevailing at Helsinki, it is expected that this strain will breed well on the Canadian prairies and in British Columbia.

The Canada thistle stem-weevil, *Ceutorhynchus litura*, does not control Canada thistle by itself but seems to contribute to weakening its host. In June larval feeding caused a 63% reduction in root carbohydrates of attacked thistles compared to unattacked ones but there was no difference in August.

Perennial sow-thistle

The leaf-gall fly, *Cystiphora sonchi*, released in 1981, has now spread over at least 15 000 m^2 near Outlook, Sask. The population density tripled near the release spot over last year. In Nova Scotia, 30 900 larvae and pupae were released; many galls were produced in two generations.

In laboratory experiments, 2% of *C. sonchi* larvae survived flooding for up to 8 weeks, and 12% were able to emerge from soil with only 4% moisture content. This indicates that the leaf-gall fly can survive extreme moisture conditions that are common in areas where sow-thistle thrives, such as the parkbelt region of the Canadian prairies.

WEED ECOLOGY AND PHYSIOLOGY

Winter wheat survey

The first assessment in Saskatchewan of the weed problems facing winter wheat growers indicated that annual and perennial grasses, such as wild oats and green foxtail, were the most common component of the weed spectrum and that broadleaf winter annual and biennial species, such as shepherd's-purse, stinkweed, and flixweed, were the next most important group. Over half of the growers rated their weed problem as moderate or severe. A spring application of 2,4-D was the most commonly used herbicide treatment and this treatment adequately controlled many of the summer annual broadleaf species. Very few of the producers used a herbicide treatment that would control either the grassy weeds or the winter annual weeds, mainly because of a lack of registered products. The information gained from the survey will assist in the development of improved weed control methods for this important alternative crop on the Canadian prairies.

Mustard, lentil, and dry pea survey

The first Saskatchewan survey of weeds in mustard, lentil, and dry pea crops indicated that green foxtail, the most common weed in mustard, was more than twice as abundant as stinkweed, which ranked first in lentil and dry pea. It was only marginally more common than shepherd's-purse in the pea crop, but in lentil stinkweed was about 1.5 times more abundant than second place wild oats. Stinkweed, wild oats, and wild buckwheat were among the top four weeds for all three crops.

A questionnaire was sent to growers following the field survey. The ranking of weed problems from growers' responses corresponded closely to the field survey results for the most abundant weeds. Two exceptions were lamb's-quarters in mustard, which was 5th most abundant in the field survey but only ranked 20th by growers, and wild buckwheat in dry pea, which was 11th in the growers' ratings and 4th in the field survey. Almost 60% of the mustard fields, 64% of the lentil fields, and 93% of the dry pea fields received both herbicide treatment and fertilizer. An additional 25%, 24%, and 7%, respectively, of the mustard, lentil, and dry pea fields received herbicide only. The most popular herbicide treatment for mustard was trifluralin; in the lentil crop, metribuzin was the most common herbicide. Uses of 4-chloro-2-methylphenoxyacetic acid (MCPA), trifluralin, and sethoxydim were approximately equal on dry pea fields.

All of the dry pea crop reported, nearly 75% of the lentil crop reported, and slightly over 50% of the mustard crop reported were seeded into stubble. In lentil, 58% of the seeded stubble received no prior cultivation. The proportions of stubble seeded to mustard and dry pea that were not tilled prior to seeding were much lower, 5% and 4%, respectively.

Brush control with dicamba + 2,4-D

The ability of dicamba + 2,4-D to control aspen poplar, prickly rose, and western snowberry in the aspen parkland was investigated. Dicamba was applied at 1.5 kg/ha and 2,4-D ester or amine was applied at 2.2 kg/ha. Control was better when the ester formulation of 2,4-D was applied with dicamba. A single application of dicamba + 2,4-D ester provided satisfactory control of aspen poplar, prickly rose, and western snowberry. Excellent control was obtained when the initial application was repeated 2 years later. The average 5-year grass yield on the untreated areas was 370 kg/ha compared to 930 kg/ha on areas that were treated once with dicamba + 2,4-D ester. The grass yield increased to 1070 kg/ha when dicamba + 2,4-D ester was applied during the 1st and 3rd year of the 5-year experiment. This information will help users make a cost-benefit analysis on the use of dicamba + 2,4-D ester for brush control in pastures.

Lamb's-quarters and stinkweed

Both lamb's-quarters and stinkweed are highly susceptible to 2,4-D, yet are still among the most abundant species on the Canadian prairies. At Indian Head, plots in a wheat–wheat–fallow rotation that contained both weed species were examined. These plots had been sprayed with 2,4-D annually since 1947. From this and other studies, the mechanisms enabling lamb's-quarters and stinkweed to avoid control methods were determined.

Germination occurs intermittently throughout the summer, and there are always some survivors among late-emerging plants. Lamb's-quarters and stinkweed seeds survive in the soil for many years, and will germinate up to 39 and 20 years later, respectively. Some genotypes of these species may have developed a resistance to 2,4-D. Plants of both lamb's-quarters and stinkweed that emerge late in the growing season do not flower and produce seeds until after harvest operations. Both weed species have relatively short life cycles. Many plants mature and set seed well before the crop harvest. If during fallow years or prior to seeding, stinkweed plants flower before cultivation, they may still produce seeds. Some stinkweed seeds can be mature enough to germinate as little as 6 days after the flower opens. Stinkweed can be either a winter or summer annual. Those plants that germinate in the fall and survive the winter may flower before seeding. Stinkweed plants uprooted by cultivation can reroot themselves if the soil is moist. If stinkweed plants are clipped after flowering the seeds can continue to mature on the clipped stems. Seeds are dispersed onto fields as impurities in crop seed. Weed seeds can be carried in clods of mud on tractor tires and other farm equipment. Strips of land or small patches can be missed during spraying operations, or gusts of wind can prevent adequate amounts of spray from coming into contact with target plants. Bad weather conditions may prevent spraying at the most appropriate time for effective control.

Effect of nitrogen on glyphosate translocation in quackgrass

It has been reported that the control of quackgrass with foliar applications of glyphosate can be significantly increased by the addition of nitrogen to the herbicide solution. There is a need for more information on the factors that may determine the effectiveness of this treatment, as there is considerable variation in the extent to which control is improved by the added nitrogen.

In experiments conducted under controlled conditions, glyphosate labeled with ^{14}C was used to study the influence of both root and shoot application of nitrogen on the uptake and translocation of the herbicide. Increasing the supply of nitrogen to the roots for 3 weeks prior to the herbicide treatment increased uptake of the foliar-applied herbicide by more than 60% and caused a similar increase in the amount that was translocated into the roots. When the nitrogen supply was increased for only 4 h prior to the herbicide application, much of the glyphosate was retained in the treated leaves and there was a 40% reduction in translocation into the roots. Application of nitrogen to the leaves, as a 0.05 *M* solution of NH_4NO_3, increased the amount of the herbicide translocated into the roots by more than 50%. A similar promotion of translocation occurred whether the nitrogen and the herbicide were applied to the same part or to different parts of the treated leaf, thus indicating that the primary effect of the nitrogen was on the translocation and not on the uptake of the herbicide.

It was also shown that increasing either the concentration of the nitrogen solution or the volume applied caused visible injury to the treated leaves and that this injury was associated with a significant reduction in herbicide translocation. Further investigations are therefore required to determine the effect of such factors as dosage, method of application, and form of nitrogen on glyphosate translocation, and also to assess the practical significance of the results by conducting similar investigations under field conditions.

Wild oats

Freshly harvested seeds of three genetically nondormant populations of wild oats germinated readily in the dark at optimum temperatures. Direct or diffused light inhibited germination in seeds of all these populations. This light-induced germination inhibition was intensity dependent; the higher the light intensity, the greater the inhibition. Germination inhibition was accentuated by higher incubation temperatures, indicating an interaction between these two factors on the induction of secondary dormancy in genetically nondormant populations. This interaction may be of adaptive significance to the survival of nondormant populations.

Germination induction by piercing imbibed dormant caryopses promoted rapid elongation of the scutellum. This response was associated with the development of scutellar division in the distal region of the scutellum. The result is consistent with previous evidence that embryo water content is a limiting factor and that seed dormancy in wild oats is caused by factors that prevent the uptake of water by the embryo in the amount required for germination.

Differential responses of pure lines of wild oats to gibberellic acid (GA_3) and substituted phthalimides (experimental compounds AC-92803, AC-94377, and AC-99524) were found in germination and endosperm-mobilization studies. AC-94377 was more active at stimulating germination than AC-99524, whereas AC-92803 had little or no effect. GA_3 was most effective at inducing endosperm mobilization, followed by AC-94377, AC-99524, and AC-92803, respectively. This differential susceptibility of pure lines to phthalimides suggests that use of these compounds to deplete wild oat seed banks may increase the proportion of less responsive biotype(s) in field populations.

Substantial differences among genetically pure lines of wild oats were found in K^+ uptake rates, growth, capacity to remove K^+, and time of flowering. The differences appear to be genetically based. The short-term K^+ influxes correlate well with the degree of seed dormancy of the pure lines studied, i.e., the more dormant lines (AN 51 and AN 474) had higher fluxes than the genetically nondormant lines (SH 319 and SH 430), with CS 40 being intermediate in both characteristics. However, CS 40 was potentially the most effective competitor among populations tested.

HERBICIDE BEHAVIOR IN THE ENVIRONMENT

Exposure of ground-rig applicators to 2,4-D

Farmer exposure to 2,4-D dimethylamine salt was determined during spray operations with tractor-drawn ground-rigs, involving handling, transferring, mixing, and applying the herbicide to wheat. The 30 individual spray operations lasted 55–870 min, and involved 1–11 tank fills, and application of 6.7–88.3 kg 2,4-D acid equivalent, to 16–194 ha.

Air sampling, hand washes, and clothing patch techniques served as a basis to calculate the amount of 2,4-D available for inhalation, and deposition on the hands and under the clothing.

The calculated amount inhaled accounted for less than 2% of the calculated potential cumulative exposure, whereas deposition on the hands accounted for 80 to 90% of the potential cumulative exposure. The 2,4-D deposition on the rest of the body ranged from 10 to 20% of the potential cumulative exposure.

Urinary 2,4-D excretion accounted for 1–2% of the potential cumulative exposure. The total calculated amount of 2,4-D deposited on the body (not including the hands) and the total amount excreted in the urine were highly correlated with the number of tank fills, area sprayed, amount sprayed, and duration of the spray operation.

Herbicide persistence and degradation in soils

In the summer of 1982, 477 ha of a weapons range in northern Saskatchewan were treated with 3.38 kg/ha (active ingredient) of a granular formulation of picloram. Extensive leaching of the herbicide was noted with time. After 14 months, residues were recovered from the 60–90 cm soil depths, and after 22 months, from the 90–120 cm soil layer. After 26 months, between 138 and 396 g/ha of picloram were recovered from the top 120 cm soil depths. Loss of picloram was considered to result from leaching, with lateral movement in the ground water away from the treatment area. Picloram was detected in the top 30 cm of soils, approximately 1 km from the treatment area, when sampled 14 and 22 months following initial application. Picloram (0.25–88.3 µg/L) was recovered after 35 months from groundwater samples, collected at 120 cm, from the same off-target sites. This transfer to nontreated sites was considered to result from a combination of blowing surface soil and groundwater movement from the treated area.

The persistence of fluazifop-butyl was investigated in three Saskatchewan soils. Under laboratory conditions, in all soils with moisture levels greater than 65% of field capacity, complete hydrolysis of the ester to fluazifop acid occurred within 48 h. In air dry soils no hydrolysis took place. Breakdown of fluazifop acid was rapid in all three moist nonsterile soils with half-life periods ranging from 11 to 23 days. Analysis of small field plots, treated in May with fluazifop-butyl, indicated that after 52 weeks less than 5% of the initial treatment could be recovered in either ester or acid form from the 0–5 or 5–10 cm soil depths at any of the three locations.

The persistence and fate of $[^{14}C]$metsulfuron methyl was studied in three moist nonsterile prairie soils under laboratory conditions. With time, there was a slow loss of the herbicide and formation of 2-carboxymethylbenzenesulfonamide as degradation product. The half-life values for metsulfuron methyl appeared to be dependent upon soil pH, with a tendency to increase with increasing soil pH. Thus, the half-life of 178 days in clay (pH 7.5) was more than twice that of 70 days in a clay loam with a pH of 5.2. In a sandy loam at pH 6.8 the half-life value was 102 days. Under similar conditions, [^{14}C]chlorsulfuron underwent degradation in the clay with a half-life of 168 days, with 2-chlorobenzenesulfonamide being the major degradation product.

Minor use program

A request was made for the registration of a fall or early spring application of linuron at a maximum rate of 4 kg . ha^{-1}, when applied as a directed basal spray, to control weeds in established saskatoons. A high-performance liquid chromatography (HPLC) method was developed to determine linuron residues in saskatoon berries for which recoveries were in the order of 85% at the 10 ppb fortification level. The method was used to monitor for linuron residues in treated saskatoon berries collected at four locations in the Prairie Provinces. No linuron residues were observed in any of the treated berry samples from the four locations.

Application technology

Droplet size evaluation facilities have been established at the station to determine spray droplet size during emission and deposition under field and laboratory conditions. Equipment obtained for this purpose includes an image analysis system (Quantimet 970), a laser-based, particle-sizing system (Aerometrics, Inc.), and a monosize droplet generator (NAE). Studies, both field and laboratory, are now in progress to investigate the influence of droplet size, droplet number per unit area, and droplet concentration on the efficacy of herbicides.

SEED INCREASE AND DISTRIBUTION

In 1986 Agriculture Canada released seed of the following new varieties to the SeCan Association: 368 kg Barrier alfalfa, 1018 kg Nova oats, 1173 kg Tipu peas, 2499 kg Ellice barley, and 285 kg Jasper oats. In addition, 390 kg Roblin wheat, 40 kg S-9043 meadow bromegrass, 550 kg BW 593 wheat, and 250 kg Titan peas were released to SeCan for further increase, and 18 kg of Cutlass mustard were released through the Provincial Stock Seed Committee.

AGRONOMY

Management of winter wheat: seedling establishment

Two factors have been deemed crucial for the successful overwintering of winter wheat in western Canada, seeding depth and seeding date. Deep seeding delays emergence and results in weaker seedlings. These seedlings produce fewer leaves and accumulate less dry matter, making them more prone to winterkill and less capable of recovering from low temperature injury. Although delayed seeding under shallow-seeded conditions results in healthy plants, they usually only have a few leaves and the seedlings cannot accumulate enough dry matter to ensure successful overwintering. As well, the plants may not cold-acclimate adequately before freeze-up. Deep planting can result in lower yields, and delayed seeding invariably results in lower yields, later maturity, and more incidence of rust. Seeding date, seeding depth, and temperature all influence the position of the crown, which is determined by the length of the subcrown internode. As seeding is delayed, the soil temperature decreases and consequently the sub-crown internode is shorter and therefore the crown is deeper. The deeper the crown the weaker the seedlings and the greater likelihood of infection from soil-borne diseases.

Safening of fenoxaprop-ethyl

Grassy weed herbicides currently being used often exhibit antagonism when mixed with broad-leaved weed herbicides; reduced weed control often results. A series of greenhouse experiments conducted with fenoxaprop-ethyl (a new grassy weed herbicide for use in broad-leaved crops) showed that the herbicidal activity normally exhibited on volunteer cereals can be antagonized by using safeners in these species of crops.

The response of Neepawa and Wakooma wheat, Bonanza and Norbert barley, wild oats (*Avena fatua* L.), and green foxtail (*Setaria viridis* L. Beav.) to fenoxaprop-ethyl at 25–400 g/ha was evaluated. Neepawa wheat was the most tolerant species, green foxtail the least. The other species showed tolerance at low rates, but tolerance decreased at increasing rates of fenoxaprop-ethyl. Selectivity was modified in all species except Neepawa by the addition of four broad-leaved weed herbicides: 2,4-D, MCPA, bromoxynil, and bromoxynil plus MCPA. Enhanced species tolerance was noted with 2,4-D in Wakooma wheat and wild oats, whereas 2,4-D, MCPA, and bromoxynil plus MCPA enhanced tolerance in Bonanza and Norbert barley.

Herbicide selectivity was changed by selective antagonism or safening of fenoxaprop-ethyl with broad-leaved weed herbicides. This can be accomplished without a loss in green foxtail or wild oat control, depending on the broad-leaved weed herbicide used.

INDIAN HEAD EXPERIMENTAL FARM CENTENNIAL

The Indian Head Experimental Farm centennial celebrations included a Tillage and Soil Conservation Symposium on 14 July, which attracted people from the research, extension, and farming sectors. The 12 speakers from across western Canada touched on pertinent topics such as crop rotations, reduced tillage, fertility, soil moisture, erosion control, crop residue management, weed control, plant breeding, winter wheat, and equipment for changing tillage systems.

The Centennial Field Day on 15 July drew over 1500 people. Displays, tours, official ceremonies, and a threshing and bindering demonstration were all part of the event. Special presentations were made by Parks Canada, Environment Canada, and the Research Branch in recognition of the 100th anniversary of one of the original experimental farms in Canada.

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Departures

R.J. Ford Resigned 1 October 1986	Engineering
D.L. Woods Transferred to Beaverlodge 1 May 1986	Oilseed breeding – mustard, sunflowers

VISITING SCIENTISTS

S.J. Barber, B.Sc., M.Sc. Canola Council of Canada research associate, 1985–1986	Plant physiology
D. Bing, B.S.A. World University Service of Canada, visiting scholar	Oilseed chemistry
R.K. Gugel, B.Sc.(Adv.), M.Sc. Canola Council of Canada research associate, 1985–1986	Oilseed pathology
G.I.C. de March, D.E.A; 3rd Cycle Doctorate, Natural Sciences and Engineering Research Council, visiting fellow, 1985–1986	Plant biotechnology
W. McFadden, B.S., M.Sc. University of Saskatchewan Crop Development Centre Research Assistant	Winter wheat diseases
C.K. Qi, B.S.A. World University Service of Canada, visiting scholar	Plant breeding
J.P. Raney, B.Sc., Ph.D. Canola Council of Canada research associate, 1985–1986	Plant biochemistry

M.J. Swartz, B.Sc., M.Sc. Natural Sciences and Engineering Research Council, visiting fellow, 1985–1986	Plant biotechnology
J.N. Sachan, B.S.A., M.Sc., Ph.D. International Development Research Center, visiting fellow	Plant biotechnology
S.P. Singh, B.S.A., M.Sc., Ph.D. International Development Research Center, visiting fellow	Plant breeding
F.S. Sedun, B.Sc., M.Sc., Ph.D. Natural Sciences and Engineering Council, visiting fellow, 1986–1987	Plant biotechnology
A.S. Tiwari, B.S.A., M.Sc., Ph.D. Canadian International Development Agency – Natural Sciences and Engineering Research Council, visiting fellow	Plant breeding
B.K. Teo, B.Sc., M.Sc., Ph.D. Canola Council of Canada research associate, 1984–1986	Oilseed pathology
J. Yang, B.S.A. Chinese Ministry of Education, visiting scholar	Oilseed pathology
M.L. Zhang, B.S.A. Canadian International Development Agency – Canadian Seed Trade Association, visiting scholar	Plant breeding

Graduate students

K. Floate, B.S.A.	Entomology
M.A. Forhan, B.Sc.	Plant breeding
H.K. Love, B.S.A.	Plant breeding
H.-M. Kao, B.S.A., M.Sc.	Plant biotechnology
Y. Semeane, B.Sc.	Oilseed pathology
J.S. Schuler, B.Sc., M.Sc.	Plant breeding
R.-C. Yang, B.Sc.	Plant pathology
K. Xi, B.Sc.	Oilseed pathology

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[1] Seconded from Libraries Division, Corporate Management Branch.

[2] Seconded from Systems and Consulting Directorate, Corporate Management Branch.

[3] On educational leave, University of Saskatchewan, from 1 October 1986.

[4] On educational leave, University of Saskatchewan, from 1 May 1984.

[5] On educational leave, University of Saskatchewan, from 1 April 1984.

[6] On educational leave, University of Waterloo, from 21 September 1984.

[7] Appointed to emeritus status, 1 November 1985.

[8] On educational leave, University of Saskatchewan, from 9 September 1985.

INTRODUCTION

This report covers the results of work completed in 1986 at the Saskatoon Research Station and the Scott Experimental Farm, 160 km west of Saskatoon. Four research programs are conducted. The oilseed, forage crops, and cereal programs include research on breeding, agronomy, and control of diseases, weeds, and insects. We have the major responsibility in the Research Branch for research on rapeseed–canola and mustard. We, along with the Lethbridge and Kamloops research stations, are an integral part of the branch's research program on development of bloat-safe alfalfa. We have had major responsibility for the development of forage grasses for the northern prairies. The cereal program is mainly concerned with reducing losses from root rot in wheat and barley, and with the breeding of utility wheats. The integrated pest management program deals with the development of control systems for problem insects (i.e., grasshoppers, wireworms, wheat midges, black flies) that are not specifically restricted to any one commodity. A major objective in the program is the minimization of our dependence on insecticides for the control of these pests.

An additional 60 ha of land was purchased late in 1985 to expand the research farm at Saskatoon. New rotations established in 1986 will allow us to use better soil management and conservation practices and to avoid possible seed contamination from previous crops.

Reports and reprints of publications can be obtained from the Saskatoon Research Station, Research Branch, Agriculture Canada, 107 Science Crescent, Saskatoon, Sask. S7N 0X2; Tel. (306)343-8214.

J.R. Hay
Director

OILSEEDS

Mustard

Detoxifying mustard meal. Treatment of Brown or Oriental mustard, *Brassica juncea* (L.) Coss., with ammonia or ammonium hydroxide during the desolventizing–toasting step of commercial oil extraction, reduced the glucosinolate content by 90%. The resulting meal has a residual glucosinolate content of less than 30 μmol/g, which is similar to canola rapeseed meal. This should enable mustard meal to be used in animal feed stocks without problems of palatability or toxicity. *B. juncea* mustard has several advantages over rapeseed, which is currently the major oilseed crop of the Canadian prairies. It is more drought tolerant and less prone to shattering than rapeseed. It also has better resistance to some diseases and is more resistant to late spring frosts. Recently, sources of low erucic acid *B. juncea* mustard have been identified. This removed one constraint toward the development of mustard as an edible oilseed crop. Treatment with ammonia to reduce the glucosinolate content of the meal removes another major obstacle.

Canola

Hail damage on rapeseed. The ability of rapeseed crops (*Brassica campestris* L., and *B. napus* L.) to recover from, and compensate for, loss of plants at the early vegetative stage of development was investigated by hand-thinning plant populations established at conventional seeding rates with commercial seeding equipment. The recommended seeding rates for production of rapeseed on the prairies is 4–7 kg/ha. This will produce plant populations of 100–295 plants per square metre, depending on the rate and species, because *B. campestris* has a smaller seed size than *B. napus*. In these studies, plant density was reduced from 100–200 plants per square metre to 40 plants per square metre with less than a 20% loss in seed yield. Seeds per pod and seed weight in some instances increased with reduced plant density. However, compensation was attributed predominantly to an increased number of pods on the remaining plants, which increased from 20–90 to as many as 600. Branching increased from as few as three to, in some instances, almost 40. With reduced plant populations, there was a tendency for increased and prolonged accumulation of dry matter by the plants after flowering. The studies were carried out under essentially weed-free conditions. When assessing hail injury to rapeseed, other factors such as soil moisture, increased competition from weeds, and other injuries would have to be taken into account.

Sclerotinia stem rot caused by the fungus *Sclerotinia sclerotiorum* (Lib.) is a major disease of canola in western Canada. Extensive use of herbicides in the Prairie Provinces may influence the occurrence and severity of this disease by affecting the pathogen directly, the host, or other microorganisms in the surrounding environment. Twenty-one preemergence and postemergence herbicides used in Saskatchewan were tested on the herbicide-amended growth medium in the laboratory for effects on linear growth of mycelium and production of sclerotia by *S. sclerotiorum*. None of the herbicides stimulated mycelial growth but most of them significantly retarded growth. Significant increases over controls in total weight of sclerotia occurred with barban and ethalfluralin at 2.5–10 µg/mL, and with diclofop-methyl and benazolin at 1–10 and 10–100 µg/mL, respectively. Increases were also observed with EL5261 (Elanco Products) and nitrofen at 2.5 µg/mL and with cyanazine at 5 and 25 µg/mL.

In clay loam soil, trifluralin, triallate, and S-ethyl dipropyl carbamothiate (EPTC) at 1, 5, 10, and 20 µg/g soil did not affect significantly formation of fruiting bodies (apothecia) or the numbers of rotted sclerotia that were recovered in autoclaved or nonautoclaved soil. Viability of sclerotia, tested after incubating them for 120 days in herbicide-amended soil, declined with EPTC only at the highest rates, 20 µg/mL, but declined consistently with increasing triallate concentrations; results with trifluralin were variable.

Diseases. In 1986, radish (*Raphanus sativus* L.) was reported for the first time as a host of white rust (*Albugo candida* (Pers. ex Lév.) Ktze) in Saskatchewan. Symptoms on naturally infected plants included sporangial pustules on the leaves, spindle-shaped stem galls, and systemically infected inflorescences. Eleven cultivars of radish were inoculated in the greenhouse. Resistant plants were found in the cultivars Chinese Rose Winter, Round Black Spanish, and Burpee White. Other cultivars, including the oilseed radish Raoula, were highly susceptible.

Radish seed sown in western Canadian gardens is imported from the United States. Seed-borne oospores were identified as a possible source of primary infections. Oospores were found in 64% of 25 samples tested. Oospores from hypertrophied inflorescences of radish germinated after a period of washing in water. This is the first reported case of oospores from radish having been germinated in the laboratory.

This race of white rust can attack certain lines of *B. campestris*. It could therefore become important in western Canada if susceptible introductions of *B. campestris* were used in canola breeding programs.

Disease surveys were conducted in Saskatchewan canola fields from 1978 to 1983. Their main objective was the monitoring of the spread and severity of blackleg (*Leptosphaeria maculans* (Desm.) Ces. & de Not.), but data also were collected on foot rot or root rot (*Rhizoctonia solani* Kuhn) and various leaf diseases. The prevalence and incidence of the virulent strain of blackleg increased 10-fold in standing crops of rapeseed/canola between 1978 and 1981, but the overall yield loss from basal stem cankers was slight. The virulent strain was most prevalent in northeastern and central areas, occurring in over 40% of the fields sampled over the 4-year period. It was much less prevalent in the southeast, occurring in only 1.5% of the fields. It was not found in northern areas, from Prince Albert to Meadow Lake.

In July 1982, blackleg occurred in 67.9% of the fields surveyed. An average of 11.0% of the plants per field had blackleg leaf and stem infections, but only 0.8% of the plants had basal stem cankers. Selected fields were sampled again late in August. In these fields, yield losses varied from 0.0 to 56.6%. The estimated average yield loss for the province in 1982 was 6%. In 1983, 51.9% of the fields surveyed had blackleg-infected plants; 61.3% of the fields in central Saskatchewan, 75.0% of those in the North Battleford–Lloydminster area, and 19.4% of those in the southeastern part of the province. The average number of infected plants per field in the three areas was 12.1%, 15.0%, and 1.2%, respectively. Yield losses due to the disease were generally slight. Therefore, the only year in which a major outbreak of blackleg with basal stem canker damage occurred was in 1982. The outbreak was, however, localized.

Prevalence and incidence of foot rot were highest in 1979, when 80.7% of the fields and an average of 16.0% of the plants were affected.

Foot rot was severe in the Melfort area in 1982, with over 90% of the fields having the disease and an average of 18.2% of the plants affected per field. In 1983, the percentage of fields in which foot rot was detected declined to 50.0%, with an average of 6.7% of the plants infected per field.

Other diseases were not of major importance in these surveys. White rust (*Albugo candida* (Pers. ex Lév.) Ktze) declined in importance considerably following the release of the resistant cultivar, Tobin, in 1981.

Insects. Additional specimens of *Phyllotreta conjuncta* Gentner, a crucifer-feeding flea beetle, were collected in Saskatchewan, confirming its presence in this province. These records represent a northwestward extension of its previously known range, and indicate its considerable tolerance to cold weather. *P. conjuncta* was not found in canola or domestic mustard crops, and it is unlikely to become a pest of these crops in western Canada.

In laboratory trials, cypermethrin, a synthetic pyrethroid insecticide, exhibited a positive temperature coefficient of toxicity above 21°C against the crucifer flea beetle, *Phyllotreta cruciferae* (Goeze). The trials also indicated that the field dosage of 14–20 g/ha, formerly recommended for flea beetle control in canola, was too low.

A laboratory method was developed for rearing the false chinch bug, *Nysius ericae* (Schilling), the major vector of a yeast found in mustard crops on the Canadian prairies. The insects are reared in clear polystyrene containers on a diet of radish slices and sunflower seeds for nymphs, and canola seedlings and sunflower seeds for adults. Eggs are laid on rolls of compacted cotton, stored at 5 ± 1°C, and brought to room temperature for hatching. This rearing method provides a good population of false chinch bugs for yeast transmission studies.

SUNFLOWERS

Insects

Southerly wind systems originating in the Gulf of Mexico area can move northward over the Great Plains into Saskatchewan in 2–3 days. The influx of these southerly winds into northern latitudes during July is often accompanied by significant increases in the number of sunflower moths, *Homoeosoma electellum* (Hulst), captured in pheromone traps in Saskatchewan. Evidence strongly supports the theory that sunflower moth outbreaks in northern latitudes such as Saskatchewan are caused by migrants that are swept northward by strong southerly wind systems known to meteorologists as low-level jet winds.

In cooperative tests with the Plant Biotechnology Institute, sex pheromone components of the banded sunflower moth, *Cochylis hospes* Walsingham, have been identified as (*E*)-11-tetradecenyl acetate and (*Z*)-11-tetradecenyl acetate. Identifications were based on capillary gas chromatography, electroantennogram measurement, and mass spectrometry data. The proportion of *E*- and Z-isomers present in female abdominal tip extracts was approximately 5:1. In field experiments, traps baited with either component alone captured few or no target adults but isomeric blends ranging from 9:1 to 4:1 (*E*-*Z*) resulted in strong and specific attraction of *C. hospes* males. Pheromone-baited traps were used to survey adult male populations at several southeastern Saskatchewan locations during 1984 and 1985. In 1984, high captures were observed at only one location, but in 1985 high captures were recorded at all locations.

Insects. Microplitis mediator (Haliday) is being considered for introduction into Saskatchewan to augment the biological control of the bertha armyworm, *Mamestra configurata* Walker. So far, only *M. mediator* from central Europe, where its host *Mamestra brassicae* (Linnaeus) has two generations a year, has been studied in Canada. *M. mediator* from Finland is expected to be more suitable for release in Saskatchewan, because it would pass through only one generation a year and would presumably be more cold hardy. Important aspects of the life history and immature stages of *M. mediator* have thus been described to aid in the separation of it from native parasitoids of *M. configurata*. Since *M. mediator* has a wide host range, it could be a valuable control agent for the bertha armyworm by maintaining high field populations between outbreaks.

FORAGES

Grasses

Breeding improvement of meadow bromegrass. In recent years meadow bromegrass, *Bromus riparius* Rehm., has been found a useful pasture grass in the more moist districts of Saskatchewan and Alberta. Although the Regar cultivar from the United States was licensed in Canada in 1980, low seed yield of the strain has limited its use. Some strains recently introduced from Europe have satisfactory forage yields in pasture clipping trials and seed yields better than Regar.

Mass selection in eight strains of meadow bromegrass for plants with good seed yields and vigor resulted in strain S-9043. One strain from the USSR, S-7414, also appeared desirable. These two strains are being increased for possible registration as Canadian cultivars.

Hybrids between meadow bromegrass and smooth bromegrass, *Bromus inermis* Leyss., were easily made when flowering periods were made to coincide. The F_2 hybrid, S-9044, showed good vigor but low fertility. Three later generation hybrids and backcrosses to parents are being developed to get more uniformity and fertility. It is hoped these hybrids will lead to a better pasture type of smooth bromegrass.

Salinity tolerance in crested wheatgrass. The production of a more salt-tolerant crested wheatgrass is desirable considering the widespread use of this grass in western Canada and the prevalence of saline soils. A collection of North American and 36 Eurasian strains were compared in a greenhouse test, using saline soils from fields near Saskatoon. Soil conductivities ranged from 10.8 to 11.2 mmho/cm. Seedlings were planted in glazed crocks with drain holes plugged. Clippings were made at monthly intervals for yield comparisons.

These tests indicated that diploid Fairway-type strains, *Agropyron cristatum* (L. Gaertn.), were more salt-tolerant in general than the standard Nordan-Summit type, *A. desertorum* (Fisch. ex Link) Schult. It was also found that several North American cultivars ranked highest, suggesting that selection for yield had fortuitously incorporated superior salt tolerance.

Included in the tests were several species of known high salt tolerance such as tall wheatgrass and altai wild ryegrass, and these were superior to crested wheatgrass. Three native wheatgrasses, slender wheatgrass, northern wheatgrass, and western wheatgrass, also had tolerance above crested wheatgrass.

Legumes

Breeding bloat-safe alfalfa. Research on breeding a bloat-safe alfalfa cultivar was started at Saskatoon in 1970. At the early stages, a major effort was directed toward determining the causal factors of pasture bloat. Following several years of investigation it was concluded that an alfalfa with a slower initial rate of digestion would be bloat-safe. This was a consistent characteristic of several other bloat-safe legumes such as cicer milkvetch, sainfoin, and bird's-foot trefoil. To this end a selection procedure was developed to assess alfalfa plants for relative initial rates of digestion, using nylon bags and fistulated cattle. To date, individual alfalfa plants have been selected at Saskatoon for three consecutive generations in an attempt to develop alfalfa strains that are similar to the bloat-safe legumes in their initial rates of digestion.

In contrast to the first two cycles (generations) of selection, the third cycle of selection involved a progeny test to evaluate the parental selections. The third cycle progenies were established in a replicated field test in 1985. In 1986, a total of 206 progenies were screened for initial rate of digestion and percentage of leaching over three replicates and three cuts (June, July, August). Because digestion rates varied from day to day it was necessary to include a common check of Beaver for each day of screening. In general, the progenies were consistently lower in initial rate of digestion compared to the Beaver check, indicating that selection was effective. A total of 21 clones (parental plants) were selected on the basis of progeny performance for lowest initial rates of digestion and lowest percentage of leaching. The average initial rate of digestion of the 21 clonal polycross progenies was 85% compared to the Beaver check of 100%. Results from previous research indicate an initial rate of digestion value of bird's-foot trefoil, a bloat-safe legume, of 79%. Thus, by extrapolation from previous experiments, we have made significant progress toward the previously demonstrated threshold value of 79% partial digestion of the bloat-safe legume, bird's-foot trefoil. Prior to final selection, these progenies and their parental clones will be evaluated in 1987 for cell wall strength, using the sonication technique and cell wall thickness measurements by electron microscope technology.

In order to attain the threshold value of 79% partial digestion, it appears that a fourth cycle of selection and progeny testing is necessary. To this end, the superior selections from the third cycle are currently being intercrossed in the growth chamber to initiate a fourth cycle of selection in the spring of 1987. In the meantime, we will be formulating a cycle three synthetic to assess the relative progress in lowering bloat incidence by using fistulated cattle in pasture tests.

Forage diseases

Surveys of alfalfa fields throughout central and northern Saskatchewan in the fall of 1984 and spring of 1985 revealed that nearly every plant in every field showed symptoms of crown bud rot of alfalfa, characterized by a V-shaped, brown dry-rot extending downward from the crown into the tap root. In general, the most severe crown rot symptoms were observed in plants showing severe yellowing and wilting, but many otherwise healthy-looking plants also had large rotted areas in the plant crown.

Field trials to examine the timing of infection and disease increase were seeded at three locations in the spring of 1985. Plant samples were taken in the fall of 1985 and in the spring and fall of 1986. Crown rot incidence and severity were low in the first two rating periods, but crown rot symptoms were found in nearly all the plants examined in the fall of 1986. Infection appeared to be initiated aboveground in the dead tissue of cut stems and to spread down into the crown, although dry-rot symptoms were occasionally observed exclusively in the roots. The percentage of the crown area affected was low in most of the affected plants, but many samples contained individual plants in which more than 75% of the crown was rotted. These severely rotted plants would not be expected to survive a normal winter in Saskatchewan. All the samples came from otherwise healthy, highly productive stands. It is clear that infection leading to subsequent crown rot occurs early in the life of the alfalfa stand. These observations provide strong support for earlier suggestions that crown and root rots may be an important factor in stand decline of alfalfa.

Sweetclover weevil control

Four years of testing has proven the feasibility of using seed dressing and in-furrow granular insecticide treatments to protect seedling stands of sweetclover from sweetclover weevil damage. In field tests, seed dressings containing carbofuran, Furadan ST (three-way), and Furadan 350 (one-way), at a dosage of 70 g/ha, did not reduce seedling emergence, and provided excellent seedling protection and the highest yield of all teatments. In the laboratory bioassays, these treatments provided about 90% mortality of weevils. Seed dressings containing lindane, Vitavax, and Gammasan, at 350 g/ha, did not reduce seedling emergence, and provided significantly poorer seedling protection, about 10% less yield than the best treatments, and a high of 43% weevil mortality in the bioassay tests. Another seed dressing, isofenphos, as Amaze WP, at 140 g/ha, was highly phytotoxic and reduced emergence by 65% and yield by 25%, while providing only moderate seedling protection and about 25% weevil mortality in the bioassay tests.

Granular insecticides applied with the seed at planting time were also evaluated. Granular carbofuran, as Furadan CR10, at 280 g/ha, did not reduce seedling emergence, and provided excellent seedling protection, yield equivalent to the best treatments, and 82% mortality of weevils in the biossay tests. Higher rates of carbofuran granules, either as 5G or CR10, caused up to 44% reduction in seedling emergence, and slightly more seedling protection and weevil mortality. Turbufos, as Counter 5G at 280 g/ha, did not reduce seedling emergence, and provided intermediate seedling protection, 65% weevil mortality, and yield comparable to other good treatments. Cloethocarb, as Lance 10G at 280 g/ha, did not affect seedling emergence, and provided significantly poorer seedling protection, only 38% weevil mortality in biossay, and a yield comparable to other good treatments. None of the above insecticides is registered for the control of sweetclover weevil at the present time.

CEREALS

Common root rot

Predators. The presence and activity of soil organisms antagonistic to *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur, the causal agent of common root rot of wheat and barley, were investigated for their potential exploitation in biological control. *Thecamoeba granifera* Greeff ssp. *minor* was found to be the predominant species of hyphal-feeding amoeba in Saskatchewan soils. In addition to *C. sativus*, it also utilized other fungi as food. The average number per gram dry weight of soil was 66 in 1983 and 76 in 1984, with a range of 2–429 individuals. This population was 10 times greater than that of spore-perforating amoebae, which occurred in average numbers of six in 1983 and five in 1984. The populations of both the hyphal-feeding and the spore-perforating amoebae varied in a similar pattern over the growing season with low numbers in summer and a peak population in fall. Population levels were not affected by soil moisture and large numbers of amoebae occurred even in soils drier than the wilting point. Cropping practice did not influence numbers of amoebae and for *T. granifera* ssp. *minor* the numbers in a particular field remained similar from year to year.

Inoculum density. In a growth-room study using inoculated planting medium, the percentage of plants with symptoms and the severity of symptoms of common root rot on wheat and barley increased as the number of soil-borne conidia of *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur increased. A maximum level of disease was attained in wheat with 10–60 conidia per cubic centimetre in the soil, and in barley with 50–120 conidia per cubic centimetre in the soil. Although almost all plants showed some disease symptoms, the area displaying lesions never exceeded 70% of the surface area of subcrown internodes. As inoculum levels increased, susceptible cultivars became more severely diseased than the moderately resistant cultivars. The relatively low inoculum densities required to cause the maximum amount of disease and the fact that conidia remain viable for a long time in soil explain why short-term crop rotations are not adequate for disease control.

Seed treatment. Seeds of Cypress and Neepawa hard red spring wheats were treated with triadimenol at 0.175 and 0.3, imazalil at 0.15 and 2, and nuarimol at 0.1 and 0.15 g/kg. All three fungicides significantly reduced the severity of common root rot, *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur, on both cultivars. The treatments also caused subcrown internode length to decrease, and promoted the early development of coleoptile node tillers and the proportion of the latter that produced fertile heads.

INTEGRATED PEST MANAGEMENT

Grasshoppers

Rearing method. A method for rearing the non-diapause strain of the migratory grasshopper, based on a production-line technique, has been developed. The egg stage lasts approximately 17 days; each nymphal instar lasts 4–5 days; adult maturation takes about 7 days after the imaginal molt. Adult females lay 21–25 eggs every 3–4 days. Methods to control the spread of diseases caused by viruses, bacteria, fungi, and protozoans in these colonies have also been developed and are described in the literature.

A protozoan parasite. Gross pathological changes in Malpighian tubules of adult male *Melanoplus sanguinipes* (Fab.) infected by the protozoan *Malameba locustae* (King & Taylor) included hypertrophy, rupture of the wall, loss of pigment, and presence of melanotic lesions. Infected grasshoppers also had depleted fat bodies and were hyperactive and more resistant to the insecticide, cypermethrin.

Baits. The use of chemical insecticides on baits for the control of grasshoppers in Canada has been evaluated. Of the 10 insecticides so far tested, only dimethoate and carbofuran have provided adequate grasshopper population reduction and crop protection. Between 70 and 80% grasshopper mortality can be expected within 5 days after either one of these two chemicals is applied on bran at 2–3 kg/ha. When applied on a bait only about 25% of the active ingredient of the chemical is needed as compared to application in a liquid spray.

Environmental safety is much improved by using bait. The baits have proven safe to pollinating insects and so can be used to control grasshopper infestations in forage crops grown for seed, even when bees are foraging the same fields.

Soil applied granular insecticide. Turbufos has been applied as a granular (in furrow) treatment at seeding time. At 15 g product per 100 m row, turbufos provided good control (up to 80% mortality) of third instar *Melanoplus sanguinipes* (Fab.) for 2 weeks after spring wheat emergence. This treatment is not registered for use in Canada.

Blackflies

Monitoring. Traps with glass collecting chambers in the "head" and "body" were constructed of plywood and painted black to simulate the silhouette of a cow. These were successfully evaluated for use to monitor adult populations of black flies, *Simulium luggeri* Nicholson & Mickel, in Saskatchewan. In tests near Prince Albert, 95% of the black flies taken in the collectors were *S. luggeri*. Other black fly species collected included *S. vittatum* Fetterstedt, *S. meridionale* Riley, *S. venustum* Say, and *S. decorum* Walker. Traps baited with CO_2 collected significantly more *S. luggeri* than the unbaited traps. The chamber in the "body" collected significantly more than the one in the "head".

Pesticide application

A bran bait spreader. As previously noted, recent studies have shown the efficacy of insecticide baits against grasshoppers, using wheat bran as the carrier. Since no equipment was available for spreading the bait, a series of spreaders that could be mounted on the back of a pick-up truck were developed and tested. The final design consisted of a hopper and a ground-driven auger that carried the treated bran to a squirrel cage blower driven from the power-take-off. The air blast distributed the bran bait at rates of 2.25–13 kg/ha in a 10-m swath at variable speeds over both smooth and rough terrain.

Experimental seed treater. In plant breeding operations, it is frequently necessary to apply seed dressings to a large number of 20–25 g samples of seed before planting. Although powdered dressings are easily applied, liquid dressings must be applied in as small a volume as possible to avoid unnecessary wetting of the seed. A treater was developed which consisted of a cylindrical glass chamber with a conical bottom. The tube at the bottom is connected to a source of low-pressure air. An opening in the side of the inlet tube admits the end of a hypodermic needle, which injects the dressing material into the airstream. The seed to be treated is dumped into the chamber. The airflow through the inlet tube is adjusted to a rate which results in the smooth circulation of the seeds. The material to be applied is then injected into the airstream which atomizes the material.

Drift reduction. When a porous shroud was mounted immediately behind the boom of an agriculture sprayer, drift was reduced by 85% under moderate wind conditions. This application method provides relatively uniform application of liquid material with less operator exposure than is likely with other methods.

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Departure

D.W. Campbell, B.E., M.Sc., Ph.D. Resigned 21 August 1986	Energy

VISITING SCIENTISTS

Rohul Amin, B.S.A., M.Sc. Barani Agricultural Research and Development Project – Pakistan, August to October 1986	Chemistry
Shri Niwas Sharma, B.Sc.(Ag.Eng.) Canadian International Development Agency senior fellow, All-India Dryland Research Project, April to October 1986	Hydrology

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[2] On transfer of work to Barani Agricultural Research and Development Project, Pakistan, 15 July 1985 to 15 July 1987.

[3] Seconded from Systems and Consulting Directorate, Corporate Management Branch 1 February 1986.

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[5] Appointed Acting Head of Section 1 August 1986.

[6] On transfer of work to Commonwealth Scientific and Industrial Research Organization, Canberra, Australia, 1 August 1986 to 1 August 1987.

[7] On secondment as Acting Director, Regina Research Station.

[8] Appointed 2 January 1986.

[9] On education leave, Washington State University, Pullman, Wash., 16 August 1984 to 16 August 1987.

[10] On education leave, Utah State University, Logan, Utah, 3 September 1984 to 16 August 1987.

[11] On secondment as Program Specialist, Prairie Region, Research Branch to 1 April 1987.

[12] On education leave, University of Saskatchewan to 1 April 1987.

INTRODUCTION

The research program at Swift Current encompasses breeding, physiology, and agronomy in wheat (hard red spring, durum, and Canada prairie spring) and rye; breeding, agronomy, and pasture management in forage crops; engineering, hydrology, fertility, agrometeorology, economics, and soil chemistry in soil and water management; and turkey nutrition. Research programs are designed to solve production problems and to evaluate new opportunities that will enable Canadian farmers, especially those located in the semiarid Palliser Triangle, to maintain or improve their competitive position in domestic and foreign markets.

Examples of significant new developments include the registration of Laura hard red spring wheat, determination of the nutritive value of HY320 wheat in poultry diets, scientific advances in drought physiology in wheat, evaluations of forage grass fertilization, and assessment of soil and water management alternatives.

Mr. B.G. McConkey, hydrologist, and Mr. R.W. Luciuk, computer systems manager, joined the professional staff in 1986. Mr. G.E. Winkleman, chemist, returned from an overseas Canadian International Development Agency (CIDA) assignment in Pakistan and Dr. D.W. Campbell, engineer, resigned to undertake new duties with the Saskatchewan Power Corporation.

Cooperative research under contract arrangements with various government and non-government agencies continued in 1986. This includes support under the Canada–Saskatchewan Agri-Food Agreement (Economic Regional Development Agreement (ERDA)) and the Saskatchewan Agricultural Development Fund that complements in-house programs. Station staff continued their involvement in CIDA agricultural research and development projects in Pakistan, India, and Brazil.

This brief report contains highlights of recent findings of our research program. More detailed results can be obtained from our annual *Research Hi-Lites*, from published papers, or by direct contact with the Research Station, Research Branch, Agriculture Canada, Box 1030, Swift Current, Sask. S9H 3X2; Tel. (306) 773-4621.

B.H. Sonntag
Director

CEREAL PRODUCTION AND UTILIZATION

Wheat varieties

Laura wheat. Laura was registered in 1986 for grades of Canada Western Red Spring wheat. In the Brown and Dark Brown soil zones it has yielded more grain than all other registered hard red spring wheat cultivars. During the period 1983–1986, Laura averaged 8% more grain than Neepawa in Western Bread Cooperative tests.

The quality of protein is similar to that of Neepawa. Laura has resistance to prevalent races of leaf rust and stem rust, and moderate resistance to common root rot. It is physiologically susceptible to loose smut but has morphological resistance to this disease. Laura is susceptible to common bunt.

HY355 wheat. HY355 is a spring wheat with white kernel color. In the Brown and Dark Brown soil zones HY355 has produced an average of 8% more grain than HY320 during the period 1983–1985. It matures about 1 day earlier than HY320 and is a conventional height type. HY355 has resistance to prevalent races of leaf rust and stem rust but is susceptible to bunt and common root rot. The end-use suitability factors appear to meet the criteria for the Canada Prairie Spring wheat class. Small-scale domestic market evaluation has been initiated prior to consideration for registration.

Several experimental lines that recombine sprouting resistance and white kernel color are being evaluated in High Yielding Wheat A, B, and C level tests.

Drought physiology

Leaf rolling. Complete leaf rolling under moisture stress reduced leaf surface area by 41–48%. Leaves that were held flat during wilting lost 9–46% more water than the controls, and there was evidence of genotypic variation in the effect of rolling on water loss.

There were no consistent correlative relationships between leaf rolling score in field plots and yield and other parameters. Leaf rolling is unlikely to be of adaptive significance to wheat in environments where stress develops rapidly, but it could be of potential use where stress develops gradually or is of short duration.

Microcomputer-controlled leaf-weighing system. A completely automated weighing system was built to facilitate large numbers of repetitive wheat-leaf weighings required in a drought program. An inexpensive microcomputer controlled all operations including movement of the conveyor chain, transfer of samples to and from the balance, taring and weighing operations, and data storage. With minor modifications this weighing system can be easily applied to other types of routine weighing needed in agricultural research.

Leaf water retention. The heritability and relationship to yield of excised-leaf water retention capability was studied in durum wheat (*T. turgidum* L. var. *durum*) crosses involving the high retention parent Pelissier. Heritability of water retention characteristics ranged from 0.08 to 0.61. Simple correlations between yield and water loss from leaves tended to be low and nonsignificant. Comparisons of the yields of the 10 fastest and 10 slowest water losers within crosses and years, however, showed significant differences in all but three of 20 cases. In two of the crosses, water retention was yield-negative in low drought stress environments, but yield-positive in a high-stress environment. Retention capability tended to be yield-positive or yield-neutral in the other crosses regardless of environment.

Harvest physiology

Kernel water concentration and grades. The effects of kernel water concentration at harvest and windrow compared to artificial drying, were determined in durum and two red spring wheats.

Artificial drying of immature wheat reduced grades, primarily due to numbers of green kernels. Green kernel levels reduced grades of windrowed durum wheat in 1 of 3 years. In the absence of grade-limiting levels of green kernels, test weight limited grades of durum in 1 year, particularly in the windrowed treatment. In a separate experiment, percentages of green kernels were determined in field-scale windrowed and standing hard red spring and durum wheat crops. Percentage of green kernels declined at similar rates in standing and windrowed crops. Kernel water concentration at which the percentage of green kernels dropped to 0.75%, the maximum level tolerated in the top grades of hard red spring and durum wheat, was lower in dry years when maturity was forced than in moist years.

Kernel development and changes in falling numbers. Field experiments were conducted to compare kernel development and changes in falling numbers with maturation and weathering of recently developed triticale (× *Triticosecale* Wittmack) lines and wheat (*Triticum aestivum* L.).

The triticales tended to reach physiological maturity at higher kernel water concentrations than wheat. There were no differences in water concentration at physiological maturity between recently developed plump-seeded lines and existing shrivel-seeded cultivars. Falling numbers of wheat increased with advancing maturity, whereas those of the triticales declined, did not change, or increased. Falling numbers of the triticale cultivar Welsh decreased with advancing maturity, whereas most of the advanced lines showed relatively constant or moderately increasing falling numbers. At harvest maturity, falling numbers of most of the advanced lines were greater than those of Welsh. Falling numbers of wheat declined following weathering damage, as did those of some advanced triticale lines. Test weights of triticale and wheat were reduced about 7% by weathering.

Physiological maturity indicators. Translocations of eosin dye and ^{14}C-sucrose into wheat (*Triticum aestivum* L.) spikes were evaluated as indicators of physiological maturity. Neither was a precise indicator, as there was a lag phase of up to several days between the cessation of grain growth and dye or ^{14}C-sucrose uptake, varying with available moisture.

Poultry nutrition

Nutritive value of HY320 wheat. True metabolizable energy (TME), TMEn (nitrogen corrected TME), and total and available amino acids have been determined on six sets of paired samples of HY320 and Neepawa wheats, obtained from different locations in western Canada. Mean TME and TMEn values for the two cultivars were virtually identical. HY320 was lower in crude protein than Neepawa. Except for relatively higher phenylalanine in Neepawa, amino acid compositions were similar relative to total protein, and availability of amino acids was the same in both cultivars. Except for the difference in crude protein, HY320 and Neepawa wheats appear to be similar in the nutritional characteristics studied.

Turkey broiler nutrition. Diets with fat added at 0, 30, or 90 g/kg of diet were fed to 1800 small white turkeys from day-old to slaughter. Within each nutrient density, four energy-to-protein ratios were derived by reducing dietary protein.

Each increment in nutrient density improved body weights and feed efficiency. Increasing energy-to-protein ratio (i.e., decreasing dietary protein) reduced body weights, feed intake, and feed efficiency. Percentage of grade A carcasses improved with each increment in nutrient density and declined with increasing energy-to-protein ratio.

FORAGE PRODUCTION AND UTILIZATION

Pasture management

Effect of time of grazing. In the first crop year after seeding Russian wild ryegrass (*Elymus junceus*) the grazing days and liveweight gain per hectare with yearling steers was 134 days and 138 kg, respectively, for a grazing period beginning on 15 June. Carrying capacity was not different when grazing was started 1 May or 1 August, but beef production was lower at 60 and 84 kg/ha, respectively. In the 2nd year when all pastures were grazed continuously from 4 May, the greatest number of days grazing were obtained when grazing had been delayed until 1 August the previous year. However, date of first grazing in the first production year did not affect liveweight gain in the 2nd year nor liveweight gain or grazing days in the subsequent 2 years of grazing with steers. It was concluded that grazing of newly established Russian wild ryegrass pastures should be delayed in the 1st year until the plants are fully headed.

Seeding alfalfa. In experiments at Melfort, alfalfa (*Medicago sativa* L. cv. Beaver) was seeded with and without canola (*Brassica campestris* L. cv. Candle) as a cover crop. Canola yields in the establishment year were maximum when alfalfa and canola were mixed and planted in 15-cm rows. Alfalfa showed no consistent seed yield differences between broadcast seeding, seeding in 15-cm or 61-cm rows, or seeding with or without the companion crop.

Brush control. A carpet-covered roller was used to apply 2,4-D, 2,4-D + picloram, and glyphosate at several concentrations to regrowth of aspen and balsam poplars (*Populus tremuloides* Michx., *P. balsamifera* L.), and willow (*Salix* spp.), growing with an understory of rose (*Rosa woodsii* Lindl.), and saskatoon (*Amelanchier alnifolia* Nutt.), and to western snowberry (*Symphoricarpos occidentalis* Hook.). A concentration of 2.25% active ingredient (a.i.) of 2,4-D amine controlled aspen poplar for 3 years, but it was not satisfactory on the other species. A concentration of 0.60% + 0.07% a.i. of 2,4-D + picloram controlled both poplars and willow. A concentration of 0.53% a.i. of glyphosate controlled both poplar species adequately, but a 1.6% concentration was needed for good control of willow. None of the treatments was satisfactory on western snowberry because of poor coverage. The percentage of leaf area wetted was low, about 10%, and evidence is presented that better coverage will result in better brush control with more dilute herbicide. Short brush that is not wiped by the roller can rapidly replace the brush killed. Forage species suffered only minor and temporary damage.

SOILS AND ENVIRONMENT

N-15 studies

Spatial variability. A study was carried out on the spatial variability of natural ^{15}N abundance, total N, organic C, and C:N ratios of the surface horizons of a cultivated field and adjacent native prairie. The spatial variability of natural ^{15}N abundance was substantially lower than that of the other types of variability studied. Significant changes in total N and natural ^{15}N abundance were detected between cultivated land and native prairie. The study also indicated that changes in the natural ^{15}N abundance required fewer samples to determine the effect of cultivation and soil management on changes in N cycling than when using changes in total N content. It was concluded that in chernozemic soils, the natural ^{15}N abundance technique is a reliable indicator of changes in soil N cycling produced by cultivation and management practices.

Fate of manure N. Nitrogen contribution of manure to soils has traditionally been studied by the difference method because labeling manure nitrogen with ^{15}N is difficult and expensive. The natural ^{15}N of manure nitrogen, however, is significantly higher than that of soil nitrogen, which makes manure a low enrichment natural tracer. Based on this fact, a study was carried out to develop a method of assessing the contribution of manure-N to soils, and to compare a nitrogen balance sheet with one made by the difference method.

The results of the study indicate that it was possible to obtain complete recovery of manure-derived N in the soil when the balance sheet was calculated based on the isotope dilution method, whereas it was not possible in all cases when the difference method was used.

Manure improves soil quality. Studies were conducted to identify the influence of manure on soil characteristics that could be related to the apparent improvement in soil tilth and reported yield increases. Results indicated that manure had no effect on bulk density or hydraulic conductivity. However, manure increased the total C and humic acid (HA) content of the soil, the percentage of soil C as HA-C, the C concentration in humin, and the percentage of total soil N as humin-N. Manure significantly increased the percentage of HA-N but not humin-N present as amino acid and amino sugar-N. Manure increased amino acids and the amino sugars in the humin hydrolysate. The net rate of N mineralization and the available forms of inorganic P were all increased significantly by manure. The natural ^{15}N-abundance technique showed that a significant, though small, proportion of soil N was derived from manure. Manure had no effect on soil microbial biomass C and N, soil respiration, and the quantity of potentially mineralizable N. Applied P had no effect on N-related parameters measured; its effect on available P was not measured. It was concluded that manure increased crop yields by improving the N and P supplying power of the soil, and by improving the physical environment of the soil through its effects on the humic colloids.

Snow and fertilizer management. A 3-year study examined the effect of snow and fertilizer management for continuous zero-till spring wheat on a loam soil in southern Saskatchewan. The use of trap strips resulted in the conservation of an average of 13 mm of extra available soil water compared to stubble cut at a uniform standard height. Spring wheat yields were generally higher in the trap strip treatments compared to the short stubble. This was especially true in the drought years.

In moist years such as 1982, 1983, and 1986, deep banding urea gave about 7% higher yields than broadcasting fertilizer in the fall or spring. Spring banding produced higher yields than fall banding. The lowest yields were obtained with the fall broadcast treatment. In very dry years such as 1984 and 1985, none of the fertilizer treatments influenced yields. Response to P in this soil was very limited. This study was carried out with financial assistance from the Potash and Phosphate Institute of Canada.

Fertilizing dryland forage grasses with nitrogen for hay. The effect of fertilizing forage grasses with nitrogen was assessed in a study carried out at Swift Current and Scott, Sask. There were significant differences in dry matter yields between grass species at Swift Current, but no species × fertilizer interactions. Fertilizer applied in April generally gave the highest forage yields and N concentration, N recovery, and net returns. Yields were 11–13% greater when ammonium nitrate was used compared to when urea was used. Nitrogen recovery by the crop at both sites averaged 21%. In most years N fertilizer increased yields, but net returns varied depending on the occurrence of early spring precipitation and on the value placed on the feed. Fertilization was profitable in the wetter years but unprofitable in dry years, irrespective of the N source or site. Net returns favored the ammonium nitrate source of N. Financial assistance was provided for this study by the Western Coop Fertilizer Agronomy Committee.

ENGINEERING

Energy research. Investigations were conducted to determine appropriate diesel engine parameters for development of a dual fuel control system for agricultural use. The study concluded that a feedback signal representing engine power was an essential characteristic of a dual fuel control system. It was also concluded that engine power could be estimated by correlations with engine fuel consumption or exhaust energy rejection.

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Research Station, Beaverlodge, Alberta

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W.A. Conrad,[1] B.Sc.	Computer Systems Manager
Vacant	Librarian

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T.P. Liu, B.Sc., M.Sc., Ph.D.	Apiculture pathology
T.I. Szabo, B.A.E., M.Sc., Ph.D.	Apiculture

Experimental Farm, Fort Vermilion, Alta.

B. Siemens, B.S.A., M.Sc.	Superintendent; Forage crops
G.W. Clayton,[5] B.S.A., M.Sc.	Crop production

Departure

S.G. Bonin, B.S.A., Ph.D. Retired 1 August 1986	Head of Section; Grass breeding

VISITING SCIENTISTS

D.W. Bergstrom, B.Sc.(Agr.), M.Sc. Agricultural Research Council of Alberta	Cereal–oilseed agronomy
J.S. Dahiya, B.Sc., M.Sc., Ph.D.	Canola pathology

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[1] Appointed 1 October 1986.

[2] On 2-year secondment to the Barani agricultural research and development (BARD) project, Islamabad, Pakistan, May 1985 to May 1987.

[3] On transfer of work to Land Resource Research Centre, Ottawa, until June 1987.

[4] Acting microbiologist, May 1985 to May 1987.

[5] On educational leave, University of Saskatchewan, until April 1988.

INTRODUCTION

The Northern Research Group, comprised of the research station at Beaverlodge and the associated experimental farm at Fort Vermilion, Alta., continued its responsibility for research and technology transfer on agricultural problems in northwestern Canada, the northern half of Alberta and British Columbia plus the Yukon and Northwest Territories. The staff of approximately 50 serve an agricultural industry that deploys over 2.2 million hectares of cultivated land, with potential for 3- to 5-fold increases in cultivated land. The research is dedicated to adapting crops and cropping practices to the environment and soils of a vast region north of the 53°N latitude. Frost-free periods are short (75–110 days) but are compensated by long days during the growing season, which allows the Northern Research Group to grow an array of crops. The predominant crops are barley, canola, wheat, forage grasses and legumes for seed, and honey. There are scientists in crop breeding of barley, canola, wheat, and forage crops. Other scientists are working on soil fertility, soil physics, winter survival, weed control, plant pathology, forage herbage, forage seed production and pollination, agrometeorology, agronomy, and nitrogen fixation. In addition, apiculturists are working on breeding, management, and pathology of the honey bee.

Strengthening the resources of the federal government are funds received from clients such as Alberta's Farming for the Future (seven projects) and the Alberta Research Council (two projects). The clients, who range from individual producers to producer groups to agri-business and provincial agencies, participate in all levels of research and development including identifying problems, planning and evaluating research proposals, and assessing results. It is having these contacts that allows the Northern Research Group to target its efforts to regional problems and solutions within the context of broader national objectives and guidelines.

The brief reports that follow give results of some research completed in 1986. Detailed information can be obtained from the publications listed in the report or by correspondence with individual research scientists or the station director. The addresses are Research Station, Research Branch, Agriculture Canada, Box 29, Beaverlodge, Alta., T0H 0C0; Tel. (403) 354-2212, and Experimental Farm, Research Branch, Agriculture Canada, Fort Vermilion, Alta., T0H 1N0; Tel. (403) 927-3253.

J.D. McElgunn
Director

APICULTURE

Pathology

Nosema apis spores were germinated readily with physiological medium, following air drying on non-imhibitory glass surfaces. Stable sporoplasms with active granular cytoplasm were formed. Cytoplasmic activity was maintained in vitro for periods of up to 7 days. Sporoplasms demonstrated nonuniform osmotic sensitivity, with a proportion of the organisms remaining stable and active in media of widely differing osmotic potential. *N. apis* spores, polar tubes, sporoplasms, and cytoplasmic contents were antigenic, showing all features by means of indirect immunofluorescence staining.

Management

A modified Alberta nucleus hive. Four styrofoam nuclei, each with an inside volume of 3.9 L, are placed on a pallet and closed with one common insulated cover. Each nucleus contains three frames (178 × 130 mm each) and a frame feeder. The frames are covered with a roofing material inner cover. A small opening (13 × 25 mm) in the inner cover provides an access for queen or queen cell introduction. A small screen on the front of the hive provides ventilation when the entrance is closed.

Scanning electron microscopy study on female mite. The peritreme of the adult female mite *Varroa jacobsoni* is located laterally above coxa III and is enclosed within a cuticular peritrematal shield, which has a slit at the end. The peritreme is lined with a thick inner membrane that has numerous tooth-like projections. The outer membrane of the peritreme is thin and smooth. Between these two membranes is a layer of columnar cells. The internal structure of the peritreme in relation to the female mite's ability to adjust to different atmospheric conditions is discussed.

Solar pollen substitute feeder. A dry feeder to make pollen feeding in cold climates more feasible by using the greenhouse effect of a polyethylene shelter was designed and tested under northern conditions in early spring. Using this feeder, pollen substitutes can be fed to stimulate and maintain higher brood-rearing rates, which subsequently ensures more foragers as nectar flow begins in the spring.

FORAGES

Cell production by the leafcutting bee. Wood and polystyrene are two predominantly used nesting materials for the alfalfa leafcutting bee, *Megachile rotundata*. Bee cell production in both new and used nesting boards of these two materials was studied in the field during one growing season at two locations in the Peace River region of northern Alberta. Each nesting material was studied in a geographically isolated area within each location to minimize the influence of material preference and drift of bees between shelters.

Cell production in used material was two to three times that in new material, irrespective of the type of material. Cell viability was above 90% in all treatments but was significantly lower for new wood as compared to the other three material types, each of which supported viabilities of about 95%. The highest number of viable cells was produced in used wood. Although this number was much greater than that produced in used polystyrene, the difference in the number of viable cells for new wood and for new polystyrene was not significant. Generally, the results of this study documented superior bee reproduction in used nesting material.

The advantages of utilizing used material, however, may be offset by the possibility of disease buildup, e.g., chalkbrood, *Ascosphaera aggregata* in the nesting boards. To capitalize on the superior bee reproduction obtained with used nesting materials, effective sanitary measures must become part of standard management practices. Further research is required to determine the physical and/or chemical causes for the superior bee reproduction obtained with used nesting materials. In this study, the causes appear to have been the result of factors transmitted from the bees to the nesting material. If these factors could be identified and/or isolated, they might become commercially useful for enhancing reproductive efficiency in new, disease-free, nesting materials.

Embryogenesis and plant regeneration of Medicago spp., in tissue culture. Ten cultivars and lines of two species of alfalfa (*M. media* and *M. sativa*) were screened for their ability to produce embryos and plantlets from root and hypocotyl segments under three different tissue culture protocols. *M. media* had a higher percentage of embryogenic formation than *M. sativa*. No embryogenic formation was produced in *M. sativa*. Within *M. media*, genotypes differ in their ability to produce embryogenic calli. The frequency of embryoids resulting in plants was dependent on the quantity and quality of embryoids produced on the calli.

Mineral dynamics in perennial ryegrass as influenced by crop management and ploidy. The effects of cutting management, fertility management, and ploidy type on the apparent recovery of N, P, and K and the seasonal uptakes and concentration of several minerals by diploid and tetraploid cultivars of perennial ryegrass were studied. Significant differences were found for management systems, year, cultivar (within a ploidy level), and year × management interaction. Ploidy level had no significant effect on the mineral dynamics. The apparent recovery of N increased progressively over the years (63–71%) at the fourth cut and N at 300 kg/ha, but it remained constant at the eighth cut and N at 450 kg/ha. Apparent P recovery increased with production year from 34 to 41%. More K was recovered in the plant than was supplied by the fertilizer, despite K rates of 165 kg/ha and 248 kg/ha applied annually. The year of production (namely, environment) was the predominant controlling factor of mineral content and uptake by perennial ryegrass.

ENVIRONMENT AND SOILS

Identify hardy alfalfa. Winterkill is one of the most serious problems affecting alfalfa production in northwestern Canada. A rapid and accurate means of assessing winterhardiness is invaluable in developing new cultivars for this region. This program was designed to define some plant and environmental factors responsible for winter injury and to develop tests to identify plants with high yield potential and resistance to severe winter stress in northwestern Canada. The program has determined that the cold hardiness of alfalfa can change from year to year, depending upon the plant and/or environmental conditions during the growing season. Three factors responsible for increasing the potential for winterkill have been identified. They are (*1*) low food reserves in the roots and crowns, (*2*) water-saturated soil during the fall hardening period, and (*3*) a late flush to growth in the fall from developing crown buds. A method was developed for separating the differences in winterhardiness between cultivars under field conditions. The method consisted of defoliating test plants at frequent intervals prior to winter, then removing snow cover in early winter to induce a temperature stress. Germ plasm sources from Fort Smith and Fort Providence, N.W.T., two cultivars from the USSR (Taezhnaya and Krasnouphimskaya-6), and one synthetic from Beaverlodge (BL 78-5) demonstrated considerable potential for increased yield and persistence over adapted cultivars to reduce the effects of a stressful winter environment on alfalfa production in northwestern Canada.

PUBLICATIONS

Research

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Research Station, Lacombe, Alberta

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D.D. Jones	Administrative Officer

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G.G. Greer, B.Sc., M.Sc., Ph.D.	Microbiology
L.E. Jeremiah, B.Sc., M.S., Ph.D.	Food technology
A.C. Murray, B.Sc., Ph.D.	Biochemistry
J.A. Newman, B.Sc., Dip.An.Gen., Ph.D.	Beef cattle production
A.P. Sather, B.Sc., M.Sc., Ph.D.	Swine production and management
A.L. Schaefer, B.Sc., M.Sc., Ph.D.	Physiology of meat animal growth and behavior
A.K.W. Tong, B.Sc., M.Sc., Ph.D.	Beef cattle evaluation and statistics

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W.B. Berkenkamp, B.Sc., M.Sc., Ph.D.	Forage crop production and pathology
K.N. Harker, B.Sc., M.Sc.	Weed physiology
S. Kibite, B.Sc., M.Sc., Ph.D.	Barley, oat, and wheat breeding
S.S. Malhi, B.Sc., M.Sc., Ph.D.	Soil chemistry
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J.S. Taylor, B.Sc., M.Sc., Ph.D.	Crop physiology

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Soils and Crops Substation, Vegreville

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Departure

C. Pierson, B.Sc., M.Sc., Ph.D. Resigned 20 November 1986	Visiting scientist – meat science

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[1] Seconded to the Canadian International Development Agency (CIDA), Indian Drylands Research Project, Phase III, on 1 June 1985.

[2] On educational leave effective 19 August 1986.

INTRODUCTION

The Lacombe Research Station and the Soils and Crops Substation at Vegreville are responsible for regional agricultural research in the central Alberta parklands. Specifically, programs include soil reclamation and development of cropping practices for Solonetzic soils of east-central Alberta; breeding new, high-yielding, disease-resistant feed barley and oat varieties for domestic use and export; and developing soil fertility, soil management, weed control, and cropping systems for barley, oat, and canola production in the parklands. The station has regional responsibility for production and disease research of annual and perennial forage crops, for developing and evaluating hay management systems that will improve the quality of stored forages, developing management systems, and evaluating new forage species and plant growth regulators to extend the pasture season, all of which will be used by beef and dairy farmers to optimize milk and beef production per hectare. The Lacombe Research Station's mandate also includes research responsibility for regional and national programs in meats, with integrated supporting programs in pork and beef production that include developing and evaluating different muscle types of meat animals; assessing the effect of nutrition, management, and environmental stressors on growth; and assessing performance and subsequent carcass quality as well as the technical research aspects of the beef cattle and swine record of performance (ROP) testing programs. The red meats research includes developing and evaluating new procedures and techniques for improving the effectiveness of national departmental beef and swine carcass grading programs. The research also involves work on the physical, chemical, microbiological, and sensory aspects of beef and pork quality in relation to preslaughter and postslaughter conditions and carcass management, both at the meat-packing plant and at the retailer level, and with consideration given to cooking quality and other factors related to consumer acceptance of the final product.

This report summarizes the highlights of research completed in 1986. Further information on any of these research activities, reprints of publications listed in this report, and copies of previous reports may be obtained from the Research Station, Research Branch, Agriculture Canada, Bag 5000, Lacombe, Alta., T0C 1S0; Tel. (403) 782-3316.

D.E. Waldern
Director

RED MEATS AND BEEF PRODUCTION

Beef production

The relationship of sire evaluations for ease of calving and birth weight. Birth weight (BW) is closely related to ease of calving (EC) and it can be measured more accurately and objectively within the first 12–16 h. Calving data from the Foreign Breed Cattle Evaluation program were used to study the relationship of sire evaluations for BW and EC. The data consisted of 6758 calves sired by Charolais, Simmental, Limousin, Beef Master, Red Angus, and Chianina sires. Sires were evaluated within breed according to procedure used by the National Beef Sire Monitoring program. Average birth weights were 38.9, 41.1, 43.8, and 46.9 kg for the unassisted, easy pull, hard pull, and surgical category of ease of calving, respectively. The phenotypic correlations between ease of calving and birth weight averaged −0.23 with a range of −0.38 to −0.04, and the sire proofs correlations averaged −0.45 with a range of −0.90 to 0.14. These results suggest that birth weight is a valuable indirect trait to be evaluated to control calving problems.

The effects of carcass grade and sex on the lean content of beef carcasses. There is little information available on the variation of lean content with beef carcass grades. This information is a requirement in order to assess the need to develop new beef carcass grading procedures. In addition, steers (or bulls) under most conditions are considered to have a higher carcass lean content than heifers, although most comparisons have been conducted on a constant age or weight basis. Heifer ($n = 82$) and steer ($n = 89$) carcasses were compared for lean content at the same grade (Canada A1 or A2), or at the same depth of average rib fat thickness within a grade (8.5 or 12.1 mm of fat). Lean content for A1 grade carcasses was found to average 63.3% with a range of 55.6–69.2%. The corresponding figures for A2 grade carcasses were 60.0% lean and a range of 53.7–66.2%. A1 grade steer carcasses were found to contain 1.7% more lean than A1 grade heifer carcasses, but the difference was reduced to 1.2% when the comparison was made at an equal depth of rib fat (8.5 mm of fat). There were no sex differences in lean content for A2 grade carcasses. It was concluded that substantial variation in carcass lean content existed within a grade and there was considerable overlap in lean content between A1 and A2 grades. Steer carcasses had a higher lean content than heifer carcasses but only for the Canada A1 grade. This study confirms the need for a more accurate carcass evaluation system for beef cattle.

Swine

Adjustment equations for backfat in swine. Boars are traditionally evaluated at 90 kg in the ROP station test program. Backfat measurements not recorded at exactly 90 kg have to be adjusted so that a fair comparison among boars can be made. Each pig has its own specific maturation pattern. The most accurate adjustment factor should be derived from its own fat deposition curve. However, this means repeated probings are required to estimate a boar's fat deposition curve. A logical compromise is to derive adjustment factors, considering growth rate. Repeated backfat measurements recorded at 70 kg (66.5–76.7 kg), 90 kg (88.8–96.7 kg), and 110 kg (95.5–120.3 kg) were available on 335 Lacombe boars. They were arbitrarily classified into three groups (slow, average, and fast) according to their growth rate from 70 to 90 kg.

Linear regressions of backfat measurement on weight were fitted for each boar, and backfat was adjusted to 90 kg by its own specific fat deposition curve. This method (method 1), referred to as within animal adjustment, should be the ideal and most accurate adjustment equation. Adjustment equations were also derived for each of the three (slow, average, and fast) growing groups (method 2). Statistical tests indicated that the fat deposition patterns of these three groups were similar. The third method (method 3) of adjustment, $FAT_{90} = FAT - 0.1316\,(WT - 90)$, ignores the individual or the group fat deposition pattern by having only one equation for all boars. Fat measurements were adjusted to 90 kg by each of these three methods. The last two methods of adjustment (methods 2 and 3) were compared by accumulating the sum of the absolute values of the deviation from the within animal adjustment method (method 1).

The increase of accuracy due to using within growing group equations (method 2) over a pooled equation (method 3) for all boars was less than 0.022 mm, which suggests that both sets of equations are similar. However, using any of these equations to adjust back from 70 to 90 or 110 to 90 kg could result in up to 0.75 mm of bias. Further study is required to determine if this amount of bias is acceptable in terms of ranking change in boar evaluation. The similarity of the within growth rate groups suggests the same adjustment equations can be used for pigs from different growth rate groups.

Meat microbiology

Effect of blast chilling on the bacterial quality and case life of pork. The industry had claimed a significant improvement in the storage life of fresh pork as an important economic benefit in support of adopting rapid chilling technologies. Unfortunately, data to substantiate these claims was very limited. In view of this, a study was undertaken under commercial conditions to compare the effects of blast (−25°C, 1 h followed by 1°C, 23 h) and conventional (1°C, 24 h) chilling treatments on the bacterial condition of the pork carcass and the keeping quality of retail loin chops. Blast chilling was not found to produce any significant change in the number of psychrotrophic or mesophilic bacteria contaminating the surface of carcasses or loins when compared to conventional chilling. Furthermore, during 7 days of retail display there were no significant differences in the numbers of bacteria (psychrotrophs and mesophiles) or rates of bacterial growth on loin chops fabricated from blast or conventionally chilled carcasses. Consequently, chilling treatment had no significant effect upon the odor or shelf life appearance of retail, loin chops. It was concluded that although blast chilling may not improve keeping quality, it can be adopted by the industry without detrimental effect upon the bacterial safety or spoilage potential of pork.

Meat quality

Effects of blast-chilling carcasses of different weight and fatness on the quality of fresh pork. The majority of pork carcasses produced in Canada are chilled at temperatures close to 1°C for a 24-h period. Two-stage chilling where carcasses are subject to extremely low temperatures ($-20°$ to $-40°C$) for short periods of time (1–3 h) prior to conventional chilling allows carcasses to be processed within a shorter period of time post-mortem than with conventional chilling. The present study was conducted to determine the influence of two-stage chilling (blast-chilling) on the color and structure of fresh pork. Pork carcasses ($n = 773$) were selected at random from the moving rail of a federally inspected abattoir approximately 35 min, following slaughter. One side of each carcass was conventionally chilled for 24 h at 1°C. The other side was blast-chilled at $-25°C$ for approximately 1 h, followed by 23 h of cooling at 1°C. Boneless pork loins and whole hams were subjectively assessed for muscle color and structure using established standards. Blast-chilled loins were significantly darker and had a firmer structure than conventionally chilled loins. Ham color was also darker for the blast-chill treatment, but chilling treatment had only a marginal effect ($P = 0.07$) on ham structure. Carcass weight and fatness had no influence on fresh pork muscle quality scores. It was concluded that blast-chilling carcasses resulted in fresh pork with a darker color and slightly firmer structure than carcasses chilled in a conventional manner.

Measurement of pork muscle quality. Agriculture Canada pork quality standards, involving a two-part scoring subjective system, have recently been described. The present study was designed to evaluate and characterize the new standards in terms of several existing objective methods for the assessment of pork muscle quality. Boneless backs (longissimus dorsi muscles), ranging in subjective structure score from one (extremely soft and exudative) to four (moderately firm and dry) were obtained from 250 carcasses at a commercial packing plant. On the 1st and 2nd days postslaughter muscle quality was evaluated. Although subjective color was highly correlated ($r = 0.91$) with subjective structure, two exceptional quality categories were noted – one with a color score of two and a structure score of one and another with a color score of three and a structure score of two. For color scores one through four, observed color changed from gray to pink to brown to red. Both subjective color and structure were highly correlated, although not necessarily linearly, with pH 24 h postslaughter, expressible juice, protein solubility, and color reflectance ($r = 0.78$–0.95). Of these measures color reflectance was most highly correlated to both subjective color ($r = 0.94$) and structure ($r = 0.95$). These standards, although suffering from the limitations of most subjective scoring systems, are an improvement upon existing subjective methods and are capable of segregating pork into several distinct muscle quality types.

Characterization of the meat quality of a halothane-positive line of swine. The Canadian swine industry continues to suffer substantial economic losses from pale, soft, and exudative (PSE) pork. A line of swine has been developed from Pietrain × Lacombe pigs based on a positive reaction to the anesthetic, halothane. This halothane-positive (H+) line will serve as a research tool for investigation of the causes of PSE pork. The meat quality of the longissimus dorsi muscle from 147 H+ pigs and 250 Lacombe pigs has been collected during the past 3 years. The meat quality of the H+ line differed considerably from that of the Lacombe breed. Based on the recently created Agriculture Canada pork quality standards, 77% of H+ pigs but only 4% of Lacombe pigs had structure scores of two or less (i.e., were slight to extremely soft and exudative). The H+ line had significantly ($P < 0.01$) paler color, lower pH at 24 h postslaughter, higher expressible juice, and higher percentage of transmission than did the Lacombe breed. To date, none of the 444 Lacombe pigs tested has reacted to the anesthetic, halothane. This would indicate that the Lacombe breed and the H+ line are likely to represent extreme pig types in the Canadian swine population and therefore are particularly suited as models for further research into the effect of stress and stress susceptibility on ultimate pork quality.

Meat processing

The effects of inherent muscle quality and frozen storage upon the processing yields of pork cuts. A total of 163 hams, 181 boneless loins, 120 picnic shoulders, and 120 boneless, skinned bellies were utilized to evaluate the effects of frozen storage and differences in inherent muscle quality on the processing yields of pork cuts under commercial conditions. The composite results of this study indicate that compared to fresh cuts, the use of frozen and thawed cuts for processing substantially reduced total processing yields (1.7 to 5.2% in hams, 4.4 to 14.3% in backs, 1.3 to 2.0% in picnics, and 2.2 to 2.7% in bellies), depending upon the inherent muscle quality. Differences in inherent muscle quality have also been shown to substantially affect the total processing yields of various fresh cuts (up to 7.7% in hams, 10.7% in backs, 4.8% in picnics, and 0.5% in bellies), and frozen and thawed cuts (up to 13.5% in hams, 20.5% in backs, 4.6% in picnics, and 0.9% in bellies), despite the fact that the differences in bellies were insufficient in magnitude to be statistically significant. Therefore, the results of this study clearly indicate that both the inherent muscle quality of cuts and the decision to use frozen and thawed cuts for processing can materially influence the profitability of pork processing operations.

Effects of inherent muscle quality differences upon the palatability and cooking properties of various fresh, cured, and processed pork products. Ham steaks, loin chops, bacon slices, shoulder roasts, and sausage patties fabricated from 168 pork carcasses representing three muscle quality groups were utilized to evaluate the effects of muscle quality on palatability and cooking properties. Irrespective of muscle quality (pale, soft, and exudative (PSE) versus normal versus dark, firm, and dry (DFD)), all pork cuts evaluated were well within the acceptable range in palatability. In addition, results indicated that inherent muscle quality differences were of little relevance to the eating quality of pork. However, meaningful differences in cooking losses were observed from loin chops and bacon slices.

PLANT AND SOIL SCIENCE

Forage crops

Use of meadow bromegrass and smooth × meadow bromegrass crosses as pasture and hay crops. Eleven meadow bromegrass (MB), smooth bromegrass (SB), and smooth × meadow bromegrass (SB × MB) lines were compared over 3 years (1983–1985) for yield, yield distribution, yield components, and productivity indices when cut frequently (four times) and infrequently (two times). MB and SB × MB lines yielded 125% and 115%, respectively, of the SB lines when cut frequently and 93% and 111%, respectively, when cut infrequently. When cut frequently, yield distribution of MB was more uniform than the other genotypes; 39%, 25%, 23%, and 13% of total yield were observed during the four growth phases. By comparison, yield distribution of frequently cut SB was 53%, 13%, 29%, and 5% of total yield. Yield of all genotypes at any cut under any system was highly dependent upon tiller size. This relationship, however, did not explain genotypic differences for regrowth and yield distribution because tiller weight of MB decreased over all cuts by about the same percentage as for SB. In SB and SB × MB yield was proportional to stem formation. In MB extra leaf production compensated for the lack of stem production, resulting in a leaf-to-stem ratio of up to 12 times greater than that exhibited by SB. Rapid regrowth in MB was partly due to new growth being initiated from the existing tillers rather than from the rhizome as in SB. Under infrequent clipping regimes SB realized its potential tiller size due to stem formation, which occurred late in the regrowth phase. During the regrowth phases of both cutting regimes dry matter production per unit leaf area of MB was 125 to 170% of SB. Yields of the SB × MB cross indicated that this genotype was suitable for both pasture and hay production. Wide crosses in *Bromus* may provide more variability from which to select improved grass types for both pasture and hay.

Weed research

Long-term quackgrass control with several graminicides. In 1985 a plot area naturally infested with quackgrass was cultivated and the front half of each plot planted to canola. Five graminicides (sethoxydim, cloproxydim, fluazifop-butyl, haloxyfop-methyl, and quizalofop-ethyl) were applied to the plots (0.25 and 0.40 kg/ha with AtPlus 411F at 0.5% v/v) and quackgrass control was evaluated. In 1986 barley was planted in the back half of the same plots with no further herbicide treatments.

At the end of the 1985 growing season quackgrass control with the aid of canola competition was good with all treatments except the 0.25 kg/ha rate of sethoxydim and cloproxydim. Without crop competition, only fluazifop-butyl, haloxyfop-methyl, and quizalofop-ethyl maintained adequate control at either application rate. At the end of the 1986 growing season, crop competition effects were masked by high plot-to-plot variability. Without crop competition quackgrass fresh weights were only different from the untreated check in plots treated with haloxyfop-methyl at 0.40 kg/ha and quizalofop-ethyl at both 0.25 and 0.40 kg/ha.

Soil fertility

Accumulation of mineral N in frozen soils during winter and its subsequent loss in early spring in central Alberta. In the Prairie Provinces, losses of nitrogen from soils have occurred since they were brought under cultivation. The losses have been reported to be much greater than can be explained by crop removal. To determine the amount of mineral N released from soils during winter, and subsequently to determine any loss of mineral N that occurred in early spring after the snow melt, 10 field experiments (eight on stubble and two on summerfallow soils) were conducted on cultivated soils in central Alberta. Soils were sampled periodically from fall to spring to a depth of 90 or 120 cm, and the samples were analyzed for NH_4-N and NO_3-N.

On stubble fields, the increase of mineral N in soils was 48 kg/ha (range of 27–83) from fall to late winter in the 60 cm depth and the value increased only to 55 kg/ha when the sampling depth was extended to 120 (or 90) cm. The mineral N change primarily occurred in the top 60 cm. The average accumulation of mineral N from the time when the soils were frozen or nearly frozen to the late winter was 31 kg/ha (range of 14–54). Loss of mineral N in early spring was 44 kg/ha (range of 18–71). The loss was apparently caused by denitrification rather than by leaching of nitrate. On summerfallow fields, both the winter accumulation and early spring loss of mineral N were greater than on stubble. The average overwinter accumulation of mineral N in summerfallow soils was 72 kg/ha, with an accumulation of mineral N in frozen soils of 53 kg/ha. Early spring loss of mineral N was 72 kg/ha.

The results suggest that the previously unknown losses of mineral N in early spring may be a major way in which soil N is lost in the Prairie Provinces. These early spring losses of mineral N from native soil N are of practical importance because the losses would accumulate over the years and consequently N fertility of soils would diminish.

Any method that reduces the release of mineral N from native soil N would be important. In the other three field experiments in north central Alberta, chemical inhibitors such as ATC (4-amino-1,2,4-triazole hydrochloride) and CS_2 applied at 22 kg/ha suppressed release of mineral N during winter and reduced the N loss in early spring. However, these chemicals may be too expensive for commercial use. Therefore, research is under way to determine the relative release of mineral N from soil N under zero and conventional tillage systems. Preliminary results indicate that there is less accumulation of mineral N under zero tillage than under conventional tillage.

SOILS AND CROPS SUBSTATION, VEGREVILLE

Solonetzic soils

Influence of gypsum and lime on biological activity of a Solonetzic soil. A study was conducted to determine the effects of added gypsum, lime, or NH_4NO_3 on microbial biomass and mineralizable carbon and nitrogen of the Ap horizon of several Solonetzic soils. The soils used were a Daugh silt loam, a Black Solonetz soil; a Malmo silt loam, a Black Solod; and a Hemaruka sandy clay loam, a Brown solodized Solonetz soil. One long-term study was sampled where treatments were applied to the Daugh and Malmo soils as follows: gypsum at 11.2 and 0.90 t/ha or ammonium nitrate at 0.90 t/ha, respectively, applied annually from 1971 to 1977. A short-term study was also conducted where the Ap horizons of the Daugh, Malmo, and Hemaruka soils were amended with increasing rates of gypsum and lime, following which they were incubated for 4 weeks. Both the long- and short-term studies indicated that added gypsum decreased the soil biomass nitrogen, increased the C-to-N ratio of the soil biomass, and reduced the rates of C and N release or mineralization. Gypsum exhibited the same influence when ammonium nitrate was added but at a higher level of activity due to the added nitrogen. The addition of lime in combination with gypsum at low rates altered this effect. Addition of gypsum and lime at very low rates resulted in an increased level of soil microbial activity. The lime either maintained or slightly increased pH as compared to addition of gypsum alone, which tends to decrease soil pH. The slightly higher pH favors increased microbial activity and thereby may prevent the adverse effects on N mineralization.

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Miscellaneous

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Research Station, Lethbridge, Alberta

PROFESSIONAL STAFF

Administration

D.G. Dorrell, B.S.A., M.Sc., Ph.D.	Director
D.L. Struble, F.E.S.C., B.A., M.A., Ph.D.	Acting Assistant Director
B.D. Clark	Acting Head, Administration
M.M. Tarnava	Personnel Officer
W.H. Mains, B.Sc.(Eng.), M.Sc.	Facilities Management Engineer

Scientific Support

J.P. Bolton, B.A., M.L.S.	Librarian
H.S. Chung, B.Sc.	Programmer-Analyst
C.M. Cutler,[1] B.A., M.L.S.	Area Coordinator, Library
T. Entz, B.Sc., M.M.	Statistician
B.S. Freeze,[2] B.S.A., M.Sc.	Bioeconomist
G.C. Kozub, B.Sc., M.Sc.	Statistician
J.C.M. L'Arrivée, B.S.A., M.Sc., Ph.D.	Technical Information Officer
D.W. Pang, Dip.C.S.	Computer System Manager
G.B. Schaalje,[3] B.S., M.S.	Statistician
L.J.L. Sears, B.A.	Scientific Editor

Animal Parasitology

J.A. Shemanchuk, C.D., F.E.S.C., B.Sc., M.Sc.	Head of Section; Biting-fly ecology
R.W. Baron,[4] B.Sc., Ph.D.	Immunology
R.H. Robertson, B.A., M.Sc.	Serology
J.L. Shipp, B.Sc., M.Sc., Ph.D.	Black-fly ecology
W.G. Taylor, B.S.P., Ph.D.	Pesticide chemistry
J.M.B. Yeung, B.Sc., Ph.D.	Pesticide metabolism

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D.R.C. Bailey, B.Sc., Ph.D.	Beef cattle breeding
K.-J. Cheng, B.Sc., M.Sc., Ph.D.	Rumen microbiology
G.H. Coulter, B.Sc.(Agric.), Ph.D.	Reproductive physiology
R. Hironaka, B.Sc., M.Sc., Ph.D.	Animal nutrition
L.A. McClelland,[5] B.Sc., M.Sc.	Sheep breeding
G.J. Mears, B.Sc., M.Sc., Ph.D.	Animal physiology
R.C. Phillippe, B.Sc.	Rumen bacteriology
L.M. Rode, B.S.A., M.S., Ph.D.	Animal nutrition
J.A.P. Vesely, B.S.A., M.S.A., Ph.D.	Sheep and dairy cattle breeding

Crop Entomology

D.L. Struble, F.E.S.C., B.A., M.A., Ph.D.	Head of Section; Insect attractants
J.R. Byers, B.S.A., M.Sc., Ph.D.	Cutworm ecology
W.A. Charnetski, B.Sc., M.Sc., Ph.D.	Insecticides
B.D. Hill, B.Sc., M.Sc., Ph.D.	Residue chemistry
D.L. Johnson, B.Sc., M.Sc., Ph.D.	Rangeland insects
K.W. Richards, B.Sc., M.Sc., Ph.D.	Insect pollinators
B.D. Schaber, B.Sc., M.Sc., Ph.D.	Forage crop pests

Plant Pathology

H.C. Huang, B.Sc., M.Sc., Ph.D.	Acting Head of Section; Forage and special crops diseases
R.L. Conner, B.S.A., Ph.D.	Cereal diseases
D.A. Gaudet, B.Sc., M.Sc., Ph.D.	Snow molds
G.A. Nelson, B.Sc., M.Sc., Ph.D.	Potato and bacterial diseases
D.W.A. Roberts, B.A., Ph.D.	Cold-hardiness physiology

Plant Science

S. Smoliak, F.S.R.M., B.Sc., M.S.	Acting Head of Section; Dryland pastures
J.R. Allan, B.Sc., M.A., Ph.D.	Aquatic plant physiology
P. Bergen, B.S.A., M.Sc., Ph.D.	Weed control
R.E. Blackshaw,[6] B.Sc., M.Sc.	Weed control
M.R. Hanna, B.S.A., M.S.A., Ph.D.	Forage legume breeding
M.S. Kaldy,[7] B.Sc., M.S., Ph.D.	Food science
G.A. Kemp, B.Sc., Ph.D.	Vegetable breeding
D.R. Lynch, B.Sc., M.Sc., Ph.D.	Potato breeding
M.D. MacDonald, B.Sc., Ph.D.	Corn breeding
D.J. Major, B.Sc., M.Sc., Ph.D.	Crop physiology
K.W. May, B.Sc., M.Sc., Ph.D.	Barley breeding
J.R. Moyer,[8] B.Sc., M.Sc., Ph.D.	Weed control
H.-H. Mundel, B.S.A., M.S., Ph.D.	New crops, Hard red spring wheat breeding
R.S. Sadasivaiah, B.Sc., M.Sc., Ph.D.	Soft white spring wheat breeding
J.B. Thomas, B.Sc., M.Sc., Ph.D.	Winter wheat breeding
E.D.P. Whelan, B.S.A., M.S.A., Ph.D.	Wheat cytogenetics
W.D. Willms, B.S.F., M.Sc., Ph.D.	Rangeland ecology

Soil Science

C.W. Lindwall, B.Sc., M.Sc., Ph.D.	Head of Section; Agricultural engineering
G.J. Beke, B.S.A., M.Sc., Ph.D.	Hydrology
J.M. Carefoot, B.S.A., M.S.A.	Irrigation agronomy
C. Chang, B.Sc., M.Sc., Ph.D.	Soil physics
J.F. Dormaar, B.S.A., M.S.A., Ph.D.	Organic chemistry
N. Foroud, B.Sc., M.Sc., Ph.D.	Irrigation engineering
B.W. Grace, B.Sc., M.Sc., Ph.D.	Agrometeorology
M.F. Hynes, B.Sc., M.Sc., Ph.D.	Microbial genetics
H.H. Janzen, B.S.A., Ph.D.	Dryland agronomy
R.M.N. Kucey, B.Sc., Ph.D.	Soil fertility
D.C. MacKay, F.C.S.S.S., B.Sc., M.S., Ph.D.	Plant nutrition
T.G. Sommerfeldt, B.Sc., M.S., Ph.D.	Drainage engineering

Onefour Substation

A.G. Ross	Farm Manager

Vauxhall Substation

B.C. Farries	Farm Manager

Departures

S.B. Arnason, B.S.A. Retired 31 December 1986	Head, Administration
A.H. Harper B.Sc., M.Sc., Ph.D. Retired 31 December 1986	Aphids
F.R. Harper B.Sc., M.Sc., Ph.D. Retired 31 December 1986	Head, Plant Pathology Section
W.O. Haufe, B.A., M.Sc., D.I.C., Ph.D. Retired 31 January 1986	Head, Animal Parasitology Section
E.E. Swierstra, B.S.A., M.S.A., Ph.D. Transferred to Brandon Research Station, 31 July 1986	Assistant Director
J. Weintraub, B.A., M.S. Retired 17 October 1986	Cattle grub ecology
G.H. Whitfield, B.Sc., M.Sc., Ph.D. Transferred to Harrow Research Station, 15 December 1986	Potato and sugar beet pests

VISITING SCIENTISTS

T.C. Channappa, Ph.D. Canadian International Development Agency (CIDA) senior fellow, India–Canada Dryland Project, May to October 1986	Hydrology
J. Chiquette, M.Sc. Agriculture Canada research scientist training fellow, August 1984 to December 1986	Rumen microbiology
D.K. Jain, Ph.D. Natural Sciences and Engineering Research Council postdoctorate fellow, September 1984 to September 1986	Nitrogen fixation
K.S. Kayande, Ph.D. CIDA senior fellow, India–Canada Dryland Project, May to October 1986	Crop physiology
H. Kudo, Ph.D. Postdoctorate fellow, September 1981 to March 1986	Rumen microbiology
U.N. Bhaskara Rao, Ph.D. CIDA senior fellow, India–Canada Dryland Project, May to October 1986	Crop physiology
D. Sabwa, M.Sc. Commonwealth scholarship doctoral student, June 1986 to June 1987	Fungal parasitism of mosquito
P.J. Scholl, Ph.D. Seconded from U.S. Department of Agriculture to the Canada–USA Sterile Insect Release Project on warble flies, March 1982 to August 1986	Integrated pest management and warble fly ecology

H.P. Singh, Ph.D. CIDA senior fellow, India–Canada Dryland Project, May to October 1986	Soil physics
Tan Khoon-Sin, Ph.D. Postdoctoral fellow, July 1986 to July 1987	Nuclear magnetic resonance (NMR) spectroscopy

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[1] Seconded from Libraries Division, Corporate Management Branch.

[2] On educational leave, Oregon State University, September 1984 to August 1987.

[3] On educational leave, North Carolina State University, August 1985 to August 1988.

[4] On transfer of work, Centre de recherches de Tours, Nouzilly, France, August 1985 to August 1986.

[5] On educational leave, Massey University, Palmerston North, New Zealand, January 1984 to January 1987.

[6] On educational leave, University of Guelph, January 1983 to January 1986.

[7] On transfer of work, U.S. Department of Agriculture Fruit and Vegetable Chemical Laboratory, Pasadena, Calif., September 1985 to September 1986.

[8] On transfer of work, Tanzania–Canada Wheat Project, Arusha, Tanzania, August 1985 to September 1987.

INTRODUCTION

The research station at Lethbridge, in southern Alberta, is located at the centre of one of the most diverse agricultural regions in Canada. A wide variety of crops is grown on both dry and irrigated land, and a major part of Canada's beef cattle industry is established on the farms and ranches within and around the region.

Station scientists conduct fundamental and applied research in support of 13 Research Branch objectives. In addition to the 500-ha site at Lethbridge, the station conducts research at a 17 000-ha ranch and beef cattle breeding station near Manyberries, a 400-ha ranch near Stavely in the foothills of the Rocky Mountains, and a 130-ha irrigation substation at Vauxhall.

Crop production and improvement research deal with the breeding and genetics of 12 different species or crop kinds, the study of the biology and control of a wide range of plant diseases and insect pests, and the development of improved agronomic practices related to soil fertility, tillage, and water use. Related studies on physical, chemical, microbiological, and hydrological aspects of soil provide guidance for the introduction of methods to maintain or improve the soil resource.

Livestock research is concerned with evaluating the effects of breed or selection methods on the improvement of beef or dairy catttle, and of breed and management on sheep productivity. Other studies on nutrition, rumen microbiology, and physiology contribute to the development of efficient methods of beef cattle production. The station is also a major centre for the study of arthropod pests of livestock.

The year 1986 was highlighted by an open house and field day to celebrate the centennial of the Research Branch and the 80th anniversary of the research station. Two major new facilities, a research feedmill and a controlled environment livestock facility, were completed, thereby enhancing our ability to conduct specialized livestock research.

During 1986, Dr. E.E. Swierstra, Assistant Director, was promoted to director of the Brandon Research Station; he was replaced by Dr. D.L. Struble, who became Acting Assistant Director in addition to his responsibilities as Head, Crop Entomology Section. Dr. G.H. Whitfield was transferred to the Harrow Research Station, and several key individuals, Mr. S.B. Arnason, Head, Administration; Dr. A.M. Harper, Entomologist; Dr. F.R. Harper, Head, Plant Pathology Section; Dr. W.O. Haufe, Head, Animal Parasitology Section; and Mr. J. Weintraub, Entomologist, retired after long and distinguished careers at Lethbridge. Dr. P.J. Scholl, U.S. Department of Agriculture scientist on the Canada–USA grub project, completed his 4-year secondment and returned to Kerrville, Tex.

Several appointments were made: Dr. C.W. Lindwall replaced Dr. D.C. MacKay as Head, Soil Science Section; Mr. J.A. Shemanchuk was named Acting Head, Animal Parasitology Section; and Mr. B.D. Clark was named Acting Head, Administration Section. The following personnel joined the staff: Mrs. M.M. Tarnava, as Administrative Officer – Personnel; Dr. M.F. Hynes, as a microbial geneticist, and Dr. J.M.B. Yeung, as an animal toxicologist.

Our scientists hosted visiting scientists and foreign delegations; participated on graduate students' thesis committees, international secondments, and exchanges; and served on numerous provincial, national, and international committees. Several of our clients participated directly in our research activities. Farming for the Future of Alberta Agriculture partially funded 11 projects and the Western Grains Research Foundation funded four projects.

The short reports that follow give results of some recent research and illustrate the types of studies that are under way. Further information may be obtained from publications listed at the end of the report or from our scientists. Correspondence or requests for reprints should be addressed to the Research Station, Research Branch, Agriculture Canada, Lethbridge, Alta., T1J 4B1; Tel. (403) 327-4561.

D.G. Dorrell
Director

ANIMAL PARASITOLOGY

Biting flies

Seasonal development of and influence of selected environmental factors on the larvae of black-fly species found in the rivers of southwestern Alberta. Larval development of *Simulium arcticum* Malloch (IIL-3), *S. defoliarti* Stone & Peterson (IIS-14.15), and *S. tuberosum* Lundstrum (FG) was documented for four rivers in southwestern Alberta from 1982 to 1984. *Simulium arcticum* (IIL-3) and *S. tuberosum* (FG) had each seven instars during larval development. Both species were multivoltine with two or three generations per year, whereas *S. defoliarti* (IIS-14.15) was univoltine. Water temperature, river discharge, and turbidity were the only environmental factors of five parameters measured that were significantly correlated with seasonal larval development of the three black-fly species. It was also speculated that food quality and availability have a direct effect on larval growth and development of black-fly species that breed in mountain rivers.

Predicting development and hatch of black-fly eggs. The influence of temperature on egg development of *Simulium arcticum* Malloch (IIS-10.11) was almost linear for temperatures from 3 to 18°C and decreased rapidly after optimum development at 18°C. A six-parameter predictive model, which has been used for other insect species, described egg development over the complete range of constant temperatures tested. A linear regression model was also used to predict egg development. This method overestimated development at the intermediate temperatures and underestimated development at the low and high temperatures. However, the linear regression model is easier to use and has been validated with field data from the Athabasca River for 1984 and 1985. At a base developmental temperature of 1.6°C, 154 and 213 degree-days are required for 50 and 90% egg hatch, respectively. The use of mathematical modeling to predict egg hatch of *S. arcticum* (IIS-10.11) in the Athabasca River will result in less emphasis on larval monitoring and a saving of time and money for the black-fly control program in Alberta.

Repellents for biting flies. To identify biochemical pathways responsible for the metabolism of the insect repellent *N*,*N*-diethyl-*m*-toluamide, more commonly known as deet, this compound was examined in an in vitro drug-metabolizing enzyme system consisting of buffered suspensions of rat liver microsomes and NADPH. In pH 8 Tris buffer and at a substrate concentration of 200 μM, metabolic reactions correspond to benzylic hydroxylation and N-deethylation, and to combinations of these reactions, resulting in the formation of two major and three minor metabolites of deet. These five metabolites were separated and detected in methyl *tert*-butyl ether extracts by capillary gas chromatography. The chemical identity of each of these degradation products was verified by comparisons with reference samples, using combined gas chromatography–mass spectrometry. A derivatization procedure with acetic anhydride facilitated the detection of metabolites with an alcohol functional group. The two major metabolites, *N*,*N*-diethyl-*m*-hydroxymethylbenzamide and *N*-ethyl-*m*-toluamide, were quantitatively determined in derivatized extracts with the use of an internal standard of *N*,*N*-dipropyl-*m*-toluamide, a nonpolar capillary column, and a nitrogen–phosphorus detector. The combined yield of these two products was 69% in three replicated experiments with liver microsomes from male Wistar rats.

Parasitism in black flies. Adults of *Simulium arcticum* (IIS-10.11) collected around cattle in central Alberta and over the Athabasca River were infected with a mermithid parasite, *Isomermis* spp. In some years up to 50% of adults were parasitized and this parasite may be a principal factor in regulating the population density of *S. arcticum* in subsequent years. Mermethid parasitism did not prevent the females from mating nor seeking and taking blood meals. Blood meals seemed to be required for maturation of the parasite. Since the parasite kills the adult black flies but does not prevent the females from taking blood meals, such a parasite could be an effective biological control agent for vector species. However, it is ineffective as a control agent for pest species such as *S. arcticum* because it does not prevent parasitized females from taking blood meals, thus causing damage to cattle.

Metabolism of insect repellent, deet. *N*,*N*-diethyl-*m*-toluamide, deet, is generally regarded as the most effective commercial insect repellent in common worldwide use.

Despite its long history of use, knowledge of the metabolism and toxicological characterization of deet remains incomplete. There have been reported cases of adverse systemic effects associated with the use of deet, especially in young human females. Thus, a simple high-performance liquid chromatographic method was developed to study the sex differences of deet metabolism. It was found that female rats metabolized deet in the same manner as male rats but at a much slower rate.

Warble grubs

Immune response to warble infestation. Cattle exposed to their third consecutive warble (*Hypoderma lineatum* and *H. bovis*) infestation had significantly reduced apparent and accumulative grub populations and produced significantly fewer grubs than animals exposed to their first infestation. These resistant animals had enhanced reactivity to mitogens (concanavalin A and pokeweed) upon reinfestation and a strong response to grub antigen at 2 months post-infestation. Their responsiveness to con A and antigen was also enhanced at 7 months post-infestation when grubs appeared in the backs and the response to antigen continued at 10 months post-infestation.

Responsiveness to mitogens in previously uninfested animals was similar to the control response throughout the infestation apart from the suppression of the con A response at 7 months post-infestation. These animals finally responded to antigen at 10 months post-infestation. These results suggest that acquired resistance to hypodermosis has a cellular basis with participation of both B- and T-cell components.

Integrated pest management for eradication of Hypoderma lineatum and H. bovis. Results from this Canada–USA project showed that spring treatments of infested cattle with the insecticide Ivermectin produced effective control of grubs. This treatment can be utilized to control infestations detected in spring inspections. Three annual releases of sterile warble flies resulted in complete eradication of *H. lineatum* and significant declines in the numbers of *H. bovis* compared with areas of insecticide-only treatment.

Impact of warble grubs on cattle in feedlots. Impact of warble grub infestations on feedlot performance of beef cattle did not produce measurable effects on cattle placed on feed from weaning to slaughter. From two to 39 grubs per animal did not influence the rate of gain, feed intake, or feed-to-gain ratio during any of the developmental stages of the grubs or in the post-infestation period. Furthermore, the grub infestations did not affect carcass grade, backfat thickness, marbling score, or ribeye area of calves, which were slaughtered 13 weeks after the last grub had vacated the host.

Gonotrophic development in warble flies. A study of gonotrophic development showed that eggs initiated and completed their growth in the larval and pupal stages. Only the primary and secondary complement of eggs developed fully. The capability to mate and immediately oviposit on host cattle is well-suited to the short life-span of the nonfeeding fly. The mean reproductive capacity of *H. lineatum* is 516 ± 53.5 eggs, which is significantly higher than the 478 ± 70.4 eggs of *H. bovis*. This system of ovarian development appears to be more efficient than that of other Diptera and contributes to the maintenance of warble grub populations, even when the adult fly populations are decimated in areas undergoing organized control.

ANIMAL SCIENCE

Beef cattle

Productive efficiency of first-cross cows in two environments. Over a 4-year period, first-cross cows sired by Charolais (C), Simmental (S), and Limousin (L) bulls and out of Hereford (H), Angus (A), and Shorthorn (N) cows, along with the Hereford × Angus (HA) were evaluated for productivity in two environments in relation to feed inputs. Range cows at Manyberries were relatively thin and averaged 4.3 mm less backfat at the start of winter and consumed 18% more energy than those in the Parkland area at Brandon.

Productive efficiency (the average weight of calves weaned per mating opportunity divided into feed energy inputs for cow winter maintenance) was greatest for SA at Brandon (7.9% > HA) and CA at Manyberries (9.3% > HA). Only CH and LA at Brandon and LA at Manyberries had less (8%) productive efficiency than the HA. Extensive comparisons on body weights, weight and backfat changes, and feed inputs by location and breed cross have been documented, and will assist producers in making decisions on breed crosses suited to specific environments.

Energy in the diet affects reproduction. Bull calves ($n = 103$) were obtained from two strains of Angus and two strains of Hereford cattle developed by selecting replacements on the basis of superior feedlot growth performance on either high- or medium-energy diets within breed. From weaning to slaughter at 12 months of age at the end of a 168-day growth performance test, bulls were fed either the high-energy (80% grain + 20% forage: 13.064 kJ/kg) or medium-energy diet (100% forage: 9.110 kJ/kg) to appetite corresponding to their strain. At 1 year of age, Angus bulls had greater paired testes weight than Hereford bulls (409 versus 330 g). Level of dietary energy did not affect either paired testes or paired epididymal weight. Compared with Hereford bulls, Angus had greater caudal epididymal sperm reserves (ESR) (4.9×10^9 versus 3.6×10^9 spermatozoa). Bulls fed the medium-energy diet during the 168-day growth performance test and slaughtered at 12 months of age had 29% greater caput-corpus ESR (4.8×10^9 versus 3.4×10^9 spermatozoa), 37% greater caudal ESR (5.2×10^9 versus 3.3×10^9 spermatozoa), and 34% greater total ESR (9.9×10^9 versus 6.5×10^9 spermatozoa) than bulls in the high-energy diet group. Thus, the sperm reserves of yearling Angus and Hereford bulls should be greater if bulls are selected and managed on a medium-energy diet rather than on a high-energy diet.

Milk production in Hereford, cattalo, and Brahman-X cows. Milk yields from Hereford ($n = 70$), cattalo ($n = 91$), and F_1 Brahman × Hereford ($n = 49$) cows were estimated at the Agriculture Canada Research Substation, Manyberries, Alta., between 1961 and 1963. Hereford and cattalo cows were grouped into 2-, 3 to 4-, 5 to 6-, and 7 to 10-year-old groups. Brahman-X cows were all 7 to 10 years of age. No differences were observed in either estimated 24-h milk yield (24HMY), or total estimated milk yield (TMY) between Hereford (1000 ± 32 kg) and cattalo (997 ± 26 kg) cows. Age of dam group had an effect in all milkings. Milk production increased with age, peaked in the 5 to 6-year-old group, and decreased thereafter. Over the 185-day lactation, cattalo calves gained slightly more than Hereford calves (138 ± 2 versus 133 ± 3 kg). Total gain was highly correlated with TMY ($r = 0.81$). Brahman-X cows 7 to 10 years of age produced more milk during all milking periods than Hereford or cattalo cows. The TMY of Brahman-X cows (1256 ± 37 kg) exceeded that of 7 to 10-year-old Hereford and cattalo cows by 207 and 225 kg. Brahman-X calves gained 166 kg over the 185-day lactation, whereas Hereford and cattalo calves gained 139 and 145 kg.

Based on these results, there is no justification to incorporate bison genes into Hereford herds to improve milk production. However, the results clearly indicate that the use of Brahman × Hereford cows would increase both milk production and beef production.

Heritability of scrotal circumference trait. Over an 8-year interval (1975 to 1982), scrotal circumference (SC) was measured on 4557 1-year-old beef bulls from 1796 sires and eight breeds. Measurements were taken upon completion of a 140-day growth performance test. During the period 1977–1983, SC was measured on 7835 2-year-old beef bulls from 2570 sires and six breeds. Two-year-old bulls were measured during reproductive examinations at spring bull sales. All SC measurements were adjusted for fixed effects of location–year and age, and heritability estimates were calculated within-breed, using a paternal half-sib analysis. Heritability estimates for the SC trait in Angus, Charolais, horned Hereford, polled Hereford, Shorthorn, Simmental, Limousin, and Maine-Anjou breeds in 1-year-old bulls were 0.22 ± 0.20, 0.46 ± 0.14, 0.89 ± 0.17, 0.83 ± 0.26, 1.01 ± 0.31, 0.63 ± 0.19, 0.94 ± 0.29, and 0.59 ± 0.22. Heritability estimates for SC in 2-year-old bulls of the first six breeds were 0.00 ± 0.21, 0.60 ± 0.25, 0.57 ± 0.07, 0.65 ± 0.10, 0.69 ± 0.34, and 0.20 ± 0.24. For several of the breed–age groups there were not large numbers of sires or sons within sires. For such groups the corresponding estimates of heritability will not be precise and should be viewed with caution. However, they can be used to indicate approximate levels of heritability for a particular breed.

Scrotal circumference of Salers bulls. Scrotal circumference measurements were taken on 255 Salers bulls located at five growth performance test stations at the 56-day (27.0 ± 0.2 cm), 84-day (28.8 ± 0.2 cm), and 140-day post-weaning weighings (30.8 ± 0.2 cm). The mean scrotal circumference measurement estimated for Salers bulls at 365 days of age was 30.4 cm. Test station, percentage of Salers, sire within test station, and the covariate body weight all contributed to the variance in scrotal circumference measurements. Increased selection pressure on the scrotal circumference traits was recommended for Salers bulls.

Scrotal circumference of beef bulls. Scrotal circumference (SC) was measured on 7918 2-year-old Angus, Charolais, horned and polled Herefords, Limousin, Shorthorn, and Simmental bulls presented to culling committees at six show–sales between 1977 and 1983. Only SC data from bulls within the age range of 24 ± 4 months were used. Scrotal circumference data were corrected across breeds for the effects of location–year and sire and were adjusted to a common bull age of 730 days. The adjusted mean SC (±SE) for 2-year-old beef bulls was Simmental, 38.8 ± 0.10 cm (n = 540); Aberdeen Angus, 37.2 ± 0.09 cm (n = 629); Charolais, 36.3 ± 0.09 cm (n = 499); horned Hereford, 36.1 ± 0.03 cm (n = 3 769); polled Hereford, 35.6 ± 0.04 cm (n = 2170); Shorthorn, 34.9 ± 0.11 cm (n = 231), and Limousin, 32.2 ± 0.18 cm (n = 80). Scrotal circumference is important because it has previously been shown to be a good indicator of paired testes weight (r = 0.95) and of the amount of tissue with sperm-producing potential in young beef bulls. Recommendations of minimum acceptable SC for 2-year-old beef bulls are Simmental, 36.0 cm; Angus and Charolais, 35.0 cm; horned and polled Herefords and Shorthorn, 34.0 cm, and Limousin, 33.0 cm.

Effects of trucking on scrotal circumference. Scrotal circumference (SC) was measured both before and after 2 to 3-year-old beef bulls were trucked either medium (138 km) or long (565 km) distances. Two SC measurement techniques were used, one recommended by the Society for Theriogenology and the "slip-off" technique. No differences were observed between pre- and post-trucking SC measurements using the Theriogenology technique when bulls were trucked either medium (n = 12; 35.9 ± 0.8 versus 35.8 ± 0.7 cm) or long (n = 16; 36.5 ± 0.5 versus 36.6 ± 0.4 cm) distances. However, when the SC of the same bulls was measured using the "slip-off" technique, there was a small but significant reduction in SC for bulls trucked medium (38.0 ± 0.7 versus 37.5 ± 0.7) cm and long (38.9 ± 0.4 versus 38.6 ± 0.4 cm) distances. Bulls having SC at or below the recommended minimum standard reacted no differently to the stress of trucking than did bulls having a SC well above the standard. Errors in measurement technique, severe weather conditions, and testicular degeneration over an extended interval may contribute to the reduction in SC observed by some livestock handlers. These data support the use of the SC measurement recommended by the Society for Theriogenology because its accuracy is not affected by trucking of bulls.

Microbial digestion of chemically or physically treated high-moisture barley. Electron microscopy studies of the morphology of microbial digestion of barley demonstrated that barley is invaded by digestive bacteria through cracks in the hull, with subsequent digestion of the endosperm and then of the hull itself. Barley starch is degraded primarily by cells of the *Bacteroides* genus. Physical (rolling) or chemical (ammonia or urea) treatment accelerates the bacterial colonization and digestion of barley. Ammonia and urea give the additional benefit of preserving high-moisture barley. This preservation has the further benefit of slowing barley starch digestion and increasing the cellulose digestion of husks in comparison to physical rolling so that digestive disorders caused by rapid starch digestion may be avoided.

Rumen microbiology. Attached cells of *Bacteroides succinogenes* orient themselves in the plane of the individual cellulose fibers, and their methylcellulose-induced detachment (almost 100%) leaves grooves or pits where the cellulose has been digested. Attached cells of *Ruminococcus albus* colonize the cellulose in a looser and less regular pattern and their almost complete methylcellulose-induced detachment leaves less regular pits in the cellulose surface. However, attached cells of *Ruminococcus flavefaciens* colonize the cellulose surface in a random orientation by means of a discernible exopolysaccharide network, and their less complete methylcellulose-induced detachment leaves no residual impressions on the cellulose surface. Methylcellulose is an effective agent for detaching major rumen cellulolytic bacteria from their cellulosic substrate and this detachment halts digestion of cellulose fibers. Methylcellulose does not inhibit growth of *B. succinogenes*, *R. albus*, and *R. flavefaciens* upon substances to which the cells do not attach, e.g., soluble sugars. Thus, it is the detachment that is essentially responsible for the cessation of digestion of cellulose fibers. These data suggest that bacterial attack on highly structured cellulose fibers requires the immediate juxtaposition of cellulolytic organisms with their insoluble substrate and that, while individual species differ in both their adhesion mechanisms and their cellulolytic enzymes, factors that affect their physical association also affect cellulose digestion.

Crossbreeding. Crossbreeding dairy cattle did not improve the cow's ability to conceive or the efficiency of achieving conception. The number of dead calves delivered by purebred cows did not depend on whether or not the calf was purebred or crossbred or if it was born following the first, second, third, or fourth gestation. Placental condition, days to first service, number of services per conception, calving interval, and gestation period were almost identical for Holstein, Ayrshire, or crossbred cows. However, Holstein cows had higher mortalities of calves and more abnormal births than Ayrshire or crossbred cows.

Sheep

Insulin and growth hormone in lambs fed monensin. Plasma insulin and growth hormone (GH) were measured in 59 control and 62 monensin-treated lambs from four experiments that were conducted to determine the effect of monensin treatment on average daily gain (ADG) and gain-to-feed ratio (G/F). Plasma GH concentrations were lower in lambs that received monensin ($P < 0.05$ to 0.001). The effect was greater in ram lambs than in ewe lambs ($P < 0.03$). When monensin treatment was started when the lambs were only a few weeks old, the GH response occurred sooner than when treatment was started when the lambs were older. In some, but not all, of the experiments the lower plasma GH concentrations were associated with increases in ADG and G/F. Monensin had little effect on plasma insulin concentrations. The results indicate that the addition of monensin to the diet of growing lambs consistently lowered plasma GH concentrations, both with and without concomitant increases in ADG and G/F.

Romanov productivity. Romanov crossbred females can be very useful for increasing the production of lambs in commercial breeding flocks. They are early maturing and have high prolificacy. However, that benefit could be eroded if the Romanov crossbred males fed out for slaughter had inferior growth or carcass quality. Both growth rate and carcass quality were similar for lambs sired by Finn, Romanov, or Dorset Horn (Finn × Finn, Finn × Dorset, Dorset × Finn, Dorset × Dorset, Romanov × Finn, Romanov × Dorset, and Romanov × Western). In overall productivity, the Romanov crossed best with Western ewes.

CROP ENTOMOLOGY

Grasshoppers

Population studies. The 1986 Alberta grasshopper forecast correctly predicted the degree and decline in the grasshopper population, based on surveys of eggs and immature stages in 1984 and 1985. About 570 000 ha were treated for control in 1986 compared with about 700 000 ha in 1985. The abundance of grasshoppers will decrease slightly again in 1987 and about 500 000 ha are expected to require treatment, depending in part on the spring weather and crop conditions.

A new formulation of deltamethrin (Decis flowable) was shown to be significantly more effective than the emulsifiable concentrate. The new formulation as a spray is superior in killing grasshoppers by direct contact, by ingestion, and by secondary contact with treated vegetation. Cooperative trials with industry researchers indicated that only about one-half as much active ingredient is required with the new formulation.

Tests of five new insecticide baits indicated that chlorpyrifos and carbaryl bait were both effective for controlling grasshoppers in pastures. These insecticides performed adequately, reducing grasshopper abundance by 65–80% in most cases, at one-fifth to one-third the insecticide rates recommended for spraying.

Early and late-season applications of the grasshopper parasite *Nosema locustae* to large plots of rangeland were conducted. No significant mortality occurred when the spores were applied when grasshoppers were mature, but the late-season application increased the incidence of infection. Infection of 10% of the grasshoppers by the parasite was established for at least 31 days when roadsides were treated with bait containing the spores.

Insecticide residue chemistry

Residue dissipation studies. The deposition, persistence, and isomeric conversion of deltamethrin were measured after a 7.2-g/ha aerial application to control grasshoppers in two pastures. Mean deposition was 76% of applied, with initial deltamethrin residues of 2.1 ppmd (d = dry weight basis) on the forage and 146 μg/m^2 on the litter. Deltamethrin dissipation was biphasic and a two-compartment model was fitted to the residue data. The DT_{50} was 5.9 days for deltamethrin residues on the forage and 17 days on the litter. Small amounts of (a*R*)-deltamethrin were detected on the forage (0.06 ppmd) and on the litter (0.65 μg/m^2). Larger amounts of *trans*-deltamethrin were detected on both substrates. The trans-isomers increased exponentially until, within 14 days after application, asymptotic levels of 0.26 ppmd on the forage and 227 μg/m^2 on the litter were reached. This study estimates the residue exposure for cattle grazing on treated fields. The significance of differentiating between deltamethrin residues and those of its isomers is that the isomers are less toxic to mammals.

Cutworms

Population study. Pale western cutworm infested about 30 000 ha in southern Alberta in the spring of 1986, a decline of 75% from 1985. Costs of control and yield losses were estimated at $2.3 million. Infestations were less widespread and severe than expected because crop stands were excellent and could withstand moderate numbers of cutworms. Sex-attractant trap monitoring of pale western cutworm moths at 81 sites within a 13 000 km^2 area in the fall of 1985 enabled reliable forecasting of where infestations were most liable to occur. Moth catches in the fall of 1986 showed that the population had declined about 30% but was still high enough to cause severe infestations in the spring of 1987, particularly if conditions are dry. The monitoring program, which was initiated in 1978, has shown that a reliable measure of cutworm population levels can be obtained with sex-attractant traps and that the likelihood of outbreaks can be predicted with considerably greater precision than has been previously possible.

Monitoring of seven other pest species, including redbacked and army cutworm, and bertha armyworm, indicates that their populations are currently below economic thresholds.

Other insect pests

The brown wheat mite, *Petrobia latens*, was very abundant during May and June in some fields of barley in southern Alberta and southwestern Saskatchewan. Heavily infested fields became quite yellow as a result of feeding by the mites or of a disease they transmitted. Research in progress at Montana State University has identified a new virus disease (barley yellow streak mosaic) that is transmitted by this mite. Although the disease has not been confirmed as occurring in southern Alberta, its presence is suspected. Only fields of recropped or continuously cropped barley appeared to be affected, but little is known of the effect the mite has on yield. The mite can be controlled by chlorpyrifos, which received a temporary registration in 1986.

The greenbug, *Schizaphis graminum*, infested about 1.2 million hectares of late crops in southern Alberta and about 100 000 ha were treated for control. Durum wheat and barley appeared to be the most severely infested. This aphid is a serious pest of cereal crops in the southern States, but populations that warranted control have never previously developed in Alberta. They appear to have been carried into Alberta by a weather system and they are not expected to be a serious problem next year.

European corn borer

Population studies. A survey with pheromone-baited traps showed that the population was essentially unchanged from 1985, with very few moths captured in the Purple Springs to Cranford area. The heaviest population is near Medicine Hat and it is equivalent to that in Manitoba in 1984. Fresh market sweet corn in the Medicine Hat area was sprayed for larval control. There was no spraying of silage or grain corn and losses due to stalk breakage were estimated to be less than 3%.

The sex pheromone components of the Alberta population were identified, which confirmed that this was the Iowa strain. A potent attractant inhibitor was discovered and this compound may have been produced in trace quantities during the commercial chemical synthesis of the primary pheromone component. This would explain the erratic performance of previous commercial European corn borer pheromone blends in North America.

Special crop pests

Sugarbeet root maggot. Good control of this pest was obtained with postemergence treatments of carbofuran and chlorpyrifos. A minor use application has been submitted for registration of carbofuran as a postemergence treatment.

A seven-stage system of gonotrophic development was described for the sugarbeet root maggot. Two days at 25°C or 34 degree-days were required for newly emerged adults to mature. The description and application of this in a pest management program in sugarbeets was published.

Forage crop pests

Cultural control. Burning alfalfa stubble before regrowth in the spring significantly reduced populations of plant and lygus bugs, but only the plant bugs remained at low numbers the following year. Alfalfa weevil and aphid populations were not reduced following the burn. When alfalfa at 20–25 cm of growth was burned, plant and lygus bugs, aphids, alfalfa weevil, and several beneficial species were significantly reduced. There was no reduction of any insects the following year. The seed yields increased the year of the burn but decreased the following year. Four years of seed yields have shown no correlation to the burning regime.

Leafcutter bees

Large numbers of alfalfa leafcutter bees must be overwintered to ensure adequate supplies for crop pollination the following year. Bee cells are removed from cold storage and placed into incubators at 30°C for about 3 weeks in early June to synchronize adult bee emergence with the beginning of alfalfa bloom in the field. The duration and temperature of cold storage and subsequent incubation temperature are important factors that influence the timely emergence of adult bees. The effect of cocoons stored for 0–22 months at four constant temperatures on the survival and emergence of leafcutter bees was examined. A five-parameter model of adult emergence for storage and temperature was described. High prepupal survival and a narrow period of adult emergence during incubation were observed when cocoons were stored at 5°C for 7–10 months. For those cocoons held in storage longer than 12 months, a warmer storage temperature of 10°C provided good survival and adults emerged over a period of less than 20 days. Percentage of emergence decreased quickly after 10 months of storage at −5 and 0.5°C, and beyond 12 months at 5°C. Storage of cocoons longer than 17 months was not found to be practical because of greater than 90% mortality in the prepupae. A minimum storage period of about 2 months is required, regardless of the storage temperature, to ensure adequate survival during incubation. Beekeepers anticipating sales of surplus bee cocoons to warm-climate countries must be prepared to plan their fall management of the bees accordingly. They need to synchronize the length of storage and date of shipping with the anticipated emergence period so that emergence is at the proper stage of crop development in the receiving country.

PLANT PATHOLOGY

Wheat

Genetics of cold hardiness. Correlation between cold hardiness and low-temperature-induced, leaf-length shortening, percentage of dry matter in the leaves, prostrate growth habit, and proportions of Peak I to Peak II invertase in the leaves has been demonstrated previously. New information shows that chromosome 5A in the hardy winter wheats Winalta and Kharkov 22 MC carries at least one of the several loci controlling the expression in acclimated wheat of each of these traits. Data from a cross between Winalta and Winalta–Rescue 5A indicate linkage between the winter–spring habit locus and the loci controlling cold hardiness and prostrate growth habit.

Influence of irrigation timing on black point incidence. A 3-year field study found that timing of irrigation had a major influence on black point incidence in susceptible lines of soft white spring wheat. Irrigation during the milk or mid-dough stages resulted in significantly higher incidences of black point than final irrigation between heading and the end of flowering. Black point incidence in the resistant line SWS15 was not strongly influenced by timing of irrigation. Disease incidence was significantly higher in susceptible lines than in SWS15, regardless of when final irrigation occurred. The findings of this study indicate that black point can be minimized and high yields maintained if soft white wheat receives no irrigation after the end of flowering.

Cereal diseases

Effect of minimum tillage on the severity of common root rot in wheat. An 11-year study comparing the severity of common root rot in wheat under conventional and minimum tillage found no consistent differences between tillage treatments. Although root rot ratings tended to be lower under minimum tillage, they were significantly lower in only 2 years and significantly higher in 1 year of the study. These results demonstrate that an increase in minimum tillage practices in southern Alberta will not result in increased losses caused by common root rot.

Forage crop diseases

Dissemination of Verticillium wilt by leafcutter bees. The alfalfa leafcutter bee (*Megachile rotundata* Fabricius) was found to use leaf pieces from both healthy and diseased alfalfa plants for constructing brood cells. In addition, 30% of the bees collected from a diseased alfalfa field yielded *Verticillium albo-atrum* on isolation. Cuticle depressions on the abdomen, around the mouthparts, and elsewhere on the body were found to contain conidia of *Verticillium*, some of which had germinated, formed hyphal mats, and penetrated pollen grains that were present in the depressions. *V. albo-atrum* was also isolated from the stigmas and styles of pods collected from 2% of the alfalfa plants growing near the hive. Based on these results producers should avoid using alfalfa fields infested with verticillium wilt for seed production.

Cottony snow mold

Sclerotial (SLTB) and non-sclerotial (LTB) isolates of the cottony snow mold fungus (*Coprinus psychromorbidus* Redhead & Traquair) were compared for pathogenicity on winter wheat at temperatures from −10 to 2°C. Three distinct pathogenicity types were observed among the LTB isolates. Type A isolates were the most pathogenic, had an optimum temperature for development of −3°C, and grew slowly at −10°C. The Type B isolate was moderately pathogenic, developed optimally between 0.5 and 2°C, and was only slightly pathogenic at −5 and −7°C. Type C isolates were nonpathogenic over the incubation temperatures tested. Isolates recently collected from northern Alberta were classified as Type A isolates, even though they varied in their pathogenicity between −8 and −3°C. Among the SLTB isolates, two colonized leaves developed optimally at −3°C and were only slightly pathogenic, whereas a third isolate developed optimally between 0.5 and 2°C and was nonpathogenic. The most pathogenic Type A isolate is currently being used in a screening test to identify winter wheat genotypes resistant to this pathogen.

PLANT SCIENCE

Forage crops

Barrier alfalfa. Barrier, developed at the Lethbridge Research Station and licensed 10 February 1986, is the first Canadian alfalfa cultivar with resistance to verticillium wilt disease. It has a higher level of verticillium wilt resistance than cultivars currently available from Europe or the United States and also has good resistance to bacterial wilt. Barrier is adapted to the irrigated areas in southern Alberta and British Columbia where verticillium wilt has become a major problem in recent years. The disease resistance of Barrier should enable the productive life of alfalfa stands in these regions to be extended by several years. The new cultivar is being distributed as a general release by SeCan Association. Seed supplies are being built up rapidly and Certified seed will be available for establishment of forage stands starting in 1988.

Fifty years of range forage yields. Range forage yields obtained over a 50-year period at the Onefour Research Substation near Manyberries, in southeastern Alberta, were analyzed in relation to several climatic factors. The basic variables were precipitation, pan evaporation, temperature, hours of sunlight, and wind velocity. The precipitation from April through July was highly correlated with range forage production and this relationship could be utilized to predict the annual forage production by 1 August each year. A slightly better correlation was obtained when range forage production was related to the total of the previous September plus the current April through July precipitation. Pan evaporation totals, mean temperature, and hours of sunlight were negatively correlated with forage production, whereas wind velocity during the growing season showed a low relationship to forage production. Stepwise regression analysis showed that the inclusion of May and June mean temperatures with June and July precipitation accounted for 63% of the variation in range forage production. The predicted forage yield would be useful in making management decisions or adjustments, especially during drought periods, whereas the long-term forage yield data can be utilized in range forage models or in validating their effectiveness.

Topography affects forage production. A study was made to determine the effect of topography and litter on the variability of forage production and utilization on Rough Fescue Grasslands in the foothills region of southwestern Alberta. Forage production and utilization were estimated at monthly intervals during the grazing season in topographic zones of two fields stocked at a moderate (2.4 animal units per month (AUM) per hectare or a high (3.2 AUM per hectare) rate. Forage production was about 50% more in the subirrigated zone than on the upland zones. Among the upland zones, forage production tended to be greatest on the south aspect. Forage utilization was also greatest in the subirrigated zone but least on the south aspect. Topographic preference was highest for the subirrigated zone early in the grazing season. The effect of a high stocking rate was to minimize the preference differences among topographic zones. Litter had a significant effect on forage production (+), utilization (−), and the amount of residual forage after the grazing season (+). Litter provided a buffer which enabled the maintenance of anticipated stocking rate by providing emergency forage and enhancing production during drought.

SOIL SCIENCE

Soil management and conservation

Fertilization promotes conservation of soil productivity. In 1967, treatments of N fertilizer at 45 kg/ha were superimposed over existing long-term spring wheat rotations established at Lethbridge in 1912. Soil from the fertilizer treatments in two of these rotations, continuous wheat and fallow–wheat–wheat, was sampled and analyzed to determine long-term effects of fertilization on soil productivity. After 18 years of N fertilizer application at 45 kg/ha, N fertilizer increased soil organic matter and nitrogen contents by approximately 14% in both rotations. As well, the labile fraction of the soil organic nitrogen, which supplies most of the plant-available nitrogen for crop uptake, was increased 33% on average by N fertilization. Soil pH was only marginally reduced by N fertilization. These results demonstrate that N fertilization, in concert with good soil management practices, can make significant contributions to the replenishment of soil organic matter and to the maintenance of indigenous soil fertility.

Effect of zero tillage on soil physical properties. Conventional tillage systems have been effective for economic and reliable weed control, for incorporation of chemicals, and for appropriate seedbed preparation. But conventional tillage is often the cause of soil erosion, excessive soil moisture loss, and deterioration of soil structure. Recent studies in southern Alberta indicate that minimum and zero tillage practices offer promising alternatives to conventional tillage. However, there has been some concern about the long-term effects of zero tillage and continuous cropping on soil physical properties, especially on soil compaction. Undisturbed soil samples were collected from plots under various tillage and crop rotation treatments for determination of saturated hydraulic conductivity (HC), saturation percentage (SAT), plant available water-holding capacity (PAWHC), porosity of large pores (LAP), and soil bulk density (BD) of a clay loam soil in the tillage zone and immediately below. After 10 years of winter wheat production, tillage and crop rotation treatments had no significant effects on soil physical properties such as HC, BD, PAWHC, and LAP of the soil in the surface 30 mm and below the tillage zone (90–120 mm). The only significant effects of tillage treatment were observed for the soil at the 30 to 60-mm depth. This research indicated that soil under zero-till tends to have lower HC, higher BD, and lower PAWHC than soil under conventional till, but none of the soil properties approached the levels that would limit crop production.

Potassium availability in Chernozemic soils. Application of K fertilizers to Brown and Dark Brown Chernozemic soils has failed to increase yields of crops in experiments conducted by Lethbridge Research Station staff during the past several decades. Recent experiments with a coarse-textured Brown Chernozemic soil indicated that some 30% of the K removed by intensive cropping with alfalfa in an outdoor rainshelter was released from non-exchangeable sources when no fertilizer K was applied. With heavy K fertilization (450 kg/ha), 35% of the added K was "fixed" in non-exchangeable forms, 15% remained as exchangeable K, and 50% was taken up by the crop. Yields were not improved, and the K concentrations in the crop were only slightly increased. It is concluded that the recently glaciated soils of the Canadian prairies, because they are relatively unweathered, are capable of releasing K from unexchangeable mineral sources to meet the crops' needs. However, unnecessary fertilizer K, applied as a precautionary measure, is readily fixed, leaching or excessive uptake is prevented, and K is released for crop use when required.

Use of cattle manure containing wood shavings. A 7-year study was conducted to determine the effects of repeated annual applications of manure containing softwood shavings (M + S) at 50 t/ha on the soil and its productivity, relative to manure without shavings (M) at 50 t/ha, and nitrogen fertilizer (F) at 67 kg/ha. The electrical conductivity, organic matter, total N, and C:N ratio of the soil from the M + S and M + S + F plots to 60-cm depth were not significantly greater than those from the M plots, and in some instances they were significantly less. The NO_3-N, total, and available P content of the soil from the M + S treatment was significantly less than that from the M treatment. Immobilization of N in the M + S and M + S + F treatments was indicated. Barley (*Hordeum vulgare* L. cv. Galt), straw, and grain yields and protein content of the grain were generally greater under the M than under the M + S treatment. When N fertilizer was included in the M + S treatment (M + S + F), the yields were similar to those with M and the protein content was increased. If manure with shavings is used for fertilizer, supplemental N should be applied to offset N immobilization.

Effect of excess feedlot manure on chemical constituents of soil. The maximum recommended rates of annual manure application to nonirrigated and irrigated Brown or Dark Brown Chernozemic soils of Alberta are 27 and 67 t/ha (wet weights), respectively. With the advent of large feedlots where hundreds of cattle were on feed at one time, problems of manure disposal arose. Information on the consequences of applying manure in excess of the recommended rates was lacking. A long-term field experiment was initiated in 1973 to determine the safe loading capacity of a Lethbridge loam (Dark Brown Chernozem) with feedlot manure. Although soil C, P, and enzyme activities increased as feedlot manure additions increased, these increases diminished at triple the recommended application rates. Phosphatase activity was checked by increased labile phosphorus levels. The percentage of manure C retained decreased as feedlot manure loading increased. Feedlot manure additions, at triple the recommended level, increased the labile P as a percentage of total soil P to around 50%. Although mineralization did not keep pace with the quantities applied, the presence of undecomposed manure did not seem to have harmful effects following 10 years of manure applications.

Water and climate

Microcomputer model for improving irrigation efficiency. Optimum timing and appropriate rates of irrigation application are the major factors for improving the water use efficiency in irrigated agriculture. A user-friendly irrigation model has been developed for an IBM compatible microcomputer, which can assist irrigation farmers in improving the timing of applications and water use efficiency. Many parameters including weather, crops, soils, management practices, and soil-water-plant relationships are considered in deriving the projected date and amount of the next irrigation. The model provides the irrigation farmers with (*1*) the amount of available water remaining in the soil profile since the previous irrigation, (*2*) the rate of water use by the crop, (*3*) the time when the accumulated water use will be equal to the allowable depletion, and (*4*) the date when the field should be irrigated and how much water should be applied. The model, although complex, is quite easy to use. It offers a simplified, practical approach for improving water management for irrigation and it is an effective way of increasing water use efficiency and reducing energy inputs.

Comparison of methods to calculate potential evapotranspiration. Computer models currently in use on an operational basis in southern Alberta for soil moisture evaluation, crop yield prediction, and irrigation scheduling employ the concept of potential evapotranspiration (PE) as the driving function for the calculation of field evaporation. There are several methods of calculating PE and they generally have similar, although not identical, results. Eight of the most commonly used methods for calculating PE were compared under different climatic conditions in southern Alberta. Under conditions of low wind speed and moderate humidities the methods produced similar results. However, under dry, windy conditions estimates of PE differed widely. Analysis of daily PE values from 1983, 1984, and 1985 indicated that formulae based on only radiation and temperature were the most poorly correlated to pan evaporation ($R^2 = 0.43–0.67$). Equations that required humidity and/or wind data were better correlated ($R^2 = 0.67–0.96$). Some of the computer simulation models currently in use on an operational basis in the semiarid, windy environment of southern Alberta may be significantly underestimating evaporation by employing equations that do not account for advective energy input. PE equations that require humidity and wind data in addition to temperature and radiation values more correctly simulate real conditions in the chinook-dominated climate of southern Alberta.

Effect of irrigation methods on groundwater levels. Water tables were continuously monitored at eight sites in southern Alberta, for a period ranging from 14 to 28 years, to determine the effect of irrigation management on groundwater levels. Water tables receded during the winter months to depths below 175 cm, with the lowest levels occurring in soils with till at depths greater than 150 cm. Highest water tables were generally encountered in the spring and were caused by natural recharge. The level flooding method generally caused higher summer water tables than the sprinkling methods. Centre-pivot sprinkling occurred at only one of the sites, where it caused lower water tables than either side roll or hand-move sprinkling. Modifications to district infrastructure and to irrigation systems affected the water tables to varying extents and interfered with the evaluation of methods, particularly the sprinkling methods.

Fungi increase nutrient uptake and crop yields. The effect of vesicular-arbuscular mycorrhizal fungi (VAM) on field bean and spring wheat dry matter production and nutrient uptake was determined under greenhouse conditions. VAM increased plant dry matter production under all conditions of varied nutrient availability. VAM were found to directly increase the uptake of phosphorus, zinc, copper, and iron by field beans and of phosphorus and zinc by wheat. Increased uptake of the other nutrients measured could be calculated to be due to increased plant size. Nutrient uptake by beans as a proportion of the total amount of nutrient available increased as the amount of nutrient decreased. This was not observed for wheat, indicating differences in nutrient requirements and nutrient uptake efficiency between the crops. The beneficial effects of VAM for both crops decreased as the volume of soil available for root growth decreased, showing that the benefits of VAM are mainly in increasing the absorptive surface area of the roots. These results indicate that for a crop without a fibrous root system, VAM can greatly increase micronutrient uptake, and that factors which inhibit VAM activity could adversely affect plant growth.

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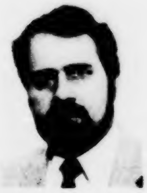
Pacific Region
Région du Pacifique

S.C. Thompson


J.B. Bole

R.Z. Rivers

J.F. Roberts

Director General *Directeur général*	S.C. Thompson, B.Sc., M.A., Ph.D., n.d.c.
Program Specialist *Spécialiste en programmes*	J.B. Bole, B.S.A., M.Sc., Ph.D.
Research Economist *Spécialiste en recherches économiques*	R.Z. Rivers, B.A., M.A.
Chief, Administration *Chef de l'administration*	J.F. Roberts

PREFACE

The Pacific Region consists of five research stations, an experimental farm, and three substations, which serve the agricultural industry in British Columbia. It has a staff of 264 people, including 60 research scientists.

During 1985 Mr. Hugh Reid, chief of Administration, and Mr. Bill Pringle, superintendent of the Prince George Experimental Farm, joined the BARD project, funded by the Canadian International Development Agency, in Islamabad, Pakistan, on a 2-year assignment. Mr. Reid was replaced by Ms. JoAnn Roberts, and Mr. Klaus Broersma is acting superintendent of the Prince George Experimental Farm.

Research conducted at the Saanichton Research and Plant Quarantine Station was transferred to the Agassiz and Vancouver stations at the year end. Management of the station was transferred to the Food Production and Inspection Branch of Agriculture Canada, who will be maintaining the critical virus indexing and plant quarantine work. Greenhouse vegetable research will now be conducted at Agassiz in closer proximity to the 85% of the industry on the mainland.

Protection research at Vancouver will be strengthened and ornamentals work discontinued. The kiwi fruit orchard at Saanichton and some overwintering of vegetable research will be maintained by staff reporting to Agassiz.

Soil management and conservation research is conducted toward a goal of assessing the extent that fertilizer, tillage, and water management limit crop production in south coastal British Columbia. More efficient techniques have been developed for correcting secondary soil acidification and for irrigation of tree fruits.

Biotechnology research, centred at the Vancouver Research Station, has developed monoclonal antibodies for sensitive diagnosis of virus diseases of plants. Genetic manipulation involving recombinant DNA techniques is used to provide enhanced resistance to diseases and pests. This basic research is leading to breakthroughs in protection of small fruits, vegetables, and potatoes. Tissue culture techniques have been developed at Saanichton for efficient virus indexing of grapes and for breeding of kiwi fruit more suited for the Canadian climate.

Plant protection research at Saanichton has resulted in biological techniques to control greenhouse insect pests and diseases while minimizing pesticide use. Integrated pest management systems are being developed at Vancouver and Summerland research stations to control virus diseases through an improved understanding of virus–host and virus–vector relationships. IPM systems for insect control in horticultural crops are being improved. Basic studies of virus structure and composition and the mechanism of establishment and multiplication of viruses are conducted with a goal of developing improved methods of controlling virus diseases.

Beef and forage research centred at the Kamloops Research Station and Prince George Experimental Farm include multidisciplinary mission-oriented studies of animal nutrition, cow–calf systems, range management, and toxic plants. Dairy research at the Agassiz Research Station seeks to develop a more precise identification of nutrient requirements for growth and lactation of dairy animals. Poultry research at Agassiz is aimed at developing management systems to reduce the incidence of sudden death syndrome and leg disorders in laying and broiler chickens.

Vegetable management research at Agassiz has included the use of protected environments or new propagation systems for over-wintering and extending the production season of field vegetables. Research is also conducted to support the registration of improved pesticides and the development of weed control practices that minimize the use of toxic chemicals. An economic analysis of vegetable research carried out in the Pacific Region showed a most probable rate of return of 20–30% for potato and vegetable research and 65% for greenhouse vegetable research.

Tree fruit research is conducted at the Summerland Research Station. New varieties of apples, peaches, and cherries have been released. The naming of the Shamrock green apple to compete with the imported Granny Smith is expected to contribute substantially to the tree fruit industry in future years. Fertilizers and growth-controlling chemicals have been tested and improved orchard floor management practices have been recommended. New strawberry and raspberry selections have been made at Vancouver.

Food processing research has resulted in improved processes for production of apple and pear juices. More efficient systems have been developed for concentrating food products at Summerland and for storage of vegetables at Agassiz.

A total of 88 scientific and 32 miscellaneous publications in 1986 transferred the results of research in the Pacific Region to colleagues and clients in Canada and the world. Further information can be obtained directly from the relevant research station or from the Research Branch Headquarters, Sir John Carling Building, Ottawa, Ont. K1A 0C5; Tel. (613) 995-7084.

S.C. Thompson
Director General

PRÉFACE

La Region du Pacifique comprend cinq stations de recherches, une ferme experimentale et trois stations satellites qui servent le secteur agricole de la Colombie-Britannique. On y a affecte 264 personnes, dont 60 chercheurs.

En 1986, M. Hugh Reid, chef de l'Administration et M. Bill Pringle, regisseur de la Ferme experimentale de Prince George, se joignaient au Projet de recherches agricoles de Barani (PRAB), qui est financé par l'Agence canadienne de développement international, à Islamabad, au Pakistan, pour un mandat de 2 ans. M^{me} JoAnn Roberts a remplacé M. Reid, et M. Klaus Broersma travaille actuellement comme régisseur intérimaire de la Ferme expérimentale de Prince George.

À la fin de l'année, les recherches menées a la Station de recherches et de quarantaine des plantes de Saanichton ont été transférées aux stations d'Agassiz et de Vancouver. La gestion de la Station releve maintenant de la Direction générale de la production et de l'inspection des aliments d'Agriculture Canada qui maintiendra un répertoire sur l'indexation des virus et sur les travaux touchant la quarantaine des végétaux. Les recherches sur les legumes de serre se feront a Agassiz, soit plus pres de la région ou l'on produit 85 % de ces produits sur le continent.

Les travaux sur la protection des vegetaux menes a Vancouver seront élargis et l'on mettra fin aux projets sur les plantes ornementales. Par ailleurs, le personnel d'Agassiz maintiendra l'exploitation du verger de kiwis de Saanichton et certaines recherches sur la survie hiémale des légumes.

Les chercheurs etudient egalement la mise en valeur et la conservation des sols pour evaluer jusqu'à quel point les engrais, le travail du sol et l'aménagement actuel des ressources hydriques peut limiter la production végétale sur la côte meridionale de la Colombie-Britannique. Ils ont mis au point des techniques plus efficaces pour corriger l'acidification secondaire du sol et pour irriguer les cultures de verger.

Concentrée à la Station de Vancouver, la recherche en biotechnologie a permis de mettre au point des anticorps monoclonaux pour le diagnostic plus sensible des viroses des plantes. Les chercheurs appliquent des techniques de recombinaison de l'ADN pour accroitre la résistance aux maladies et aux ravageurs. Ces recherches fondamentales aboutissent à des progres importants sur le plan de la protection des petits fruits, des légumes et de la pomme de terre. Les chercheurs de Saanichton ont mis au point des techniques de culture tissulaire pour l'indexation efficace des virus du raisin et la sélection de kiwis mieux adaptés au climat canadien.

Les travaux sur la protection des végétaux menés à Saanichton ont abouti à la mise au point de techniques biologiques de lutte contre les insectes ravageurs et les maladies des plantes de serre, tout en reduisant au minimum l'application de pesticides. Les stations de recherches de Vancouver et de Summerland ont elaboré des systemes de lutte intégrée pour eliminer les viroses par une meilleure comprehension des relations virus-hôtes et virus-vecteurs. Elles sont d'ailleurs en train d'ameliorer des systemes destines a combattre les insectes dans les cultures horticoles. Des recherches fondamentales sont egalement menées sur la structure et la composition du virus et sur le mecanisme d'etablissement et de multiplication de ces organismes en vue de mettre au point de meilleures methodes de lutte contre les viroses.

Les travaux sur le boeuf de boucherie et sur les fourrages menes a la Station de recherches de Kamloops et a la Ferme experimentale de Prince George englobent des études thématiques pluridisciplinaires sur la nutrition animale, les regimes d'elevage-naissage, l'amenagement des longs parcours et les plantes toxiques. A la Station d'Agassiz, on cherche une methode pour cerner avec plus de precision les besoins nutritifs associés à la croissance et a la lactation chez les bovins laitiers. On y met aussi au point des systemes d'elevage destines a reduire l'incidence du syndrome de la mort soudaine et les anomalies des pattes chez les poulets de ponte et a griller.

Les recherches sur les legumes menees a Agassiz portent sur l'utilisation de milieux protegés ou de nouveaux systemes de multiplication pour la survie hiemale et la prolongation de la periode vegetative pour les legumes de plein champ. Les travaux appuient également l'homologation de pesticides ameliorés et les chercheurs tentent de mettre au point des pratiques de lutte contre les mauvaises herbes susceptibles de reduire au minimum l'application de produits chimiques toxiques. Une analyse economique de la recherche sur les légumes, menee dans la Region du Pacifique, a revele que les etudes sur les legumes et la pomme de terre pouvaient rapporter de 20 a 30 % et même 65 % dans le cas des legumes de serre.

Les travaux menes a la Station de recherches de Summerland portent sur les cultures de verger. La Station a diffuse de nouvelles varietes de pommes, de pêches et de cerises. Ainsi, la pomme verte Shamrock devrait concurrencer la Granny Smith importee et contribuer ainsi considerablement a l'essor de ce secteur dans l'avenir. Les chercheurs ont essaye des engrais et des regulateurs de croissance et ont recommande des pratiques ameliorees de gestion des sols de verger. À Vancouver, on a selectionne de nouvelles varietes de fraises et de framboises.

La recherche sur la transformation des aliments a abouti à des procedes ameliores de production de jus de pomme et de poire. On a également mis au point des systemes plus efficaces pour concentrer les produits alimentaires (Summerland) et pour entreposer les legumes (Agassiz).

En 1986, les chercheurs de la Région du Pacifique ont diffusé 88 rapports scientifiques et 32 publications diverses et les ont envoyés à leurs collègues et à leurs clients au Canada et à l'étranger. Pour obtenir de plus amples renseignements, il faut s'adresser directement à la Station de recherches concernée ou à l'administration centrale de la Direction générale de la recherche, édifice Sir John Carling, Ottawa (Ontario), K1A 0C5. On peut également appeler au (613) 995-7084.

S.C. Thompson
Directeur général

Research Station, Agassiz British Columbia

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D. Neve, B.A.	Administrative Officer
D.H. Frey, B.Sc.	Analyst–Programmer
J. Lockyer,[1] B.A., M.L.S.	Librarian

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W.T. Buckley, B.S., Ph.D.	Ruminant mineral biochemistry
E.E. Gardiner, B.S., M.S., Ph.D.	Poultry nutrition
J.R. Hunt, B.S.A., Ph.D.	Poultry physiology
R.C. Newberry, B.Sc., Ph.D.	Animal behavior

Crop Science

P.W. Perrin, B.Sc., Ph.D.	Head of Section; Postharvest physiology
N.P. Ames-Gottfred,[2] B.S.A., M.S.A.	Forage management
J.A. Freeman, B.S.A, M.S.A., Ph.D.	Small fruits management; Weed control
S. Freyman, B.Sc.(Agr.), M.S.A, Ph.D.	Weed control
S.G. Fushtey, B.Sc., M.Sc., Ph.D.	Turf management
J.C.W. Keng, B.Sc., M.Sc., Ph.D.	Soil, water, and crop management
C.G. Kowalenko, B.S.A., M.Sc., Ph.D.	Soil biochemistry and fertility
A.R. Maurer, B.S.A., M.Sc.	Physiology of vegetable crops

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[1] **Seconded from Libraries Division, Corporate Management Branch.**

[2] **On educational leave, University of Guelph, October 1984 to June 1987.**

INTRODUCTION

The Agassiz Research Station has a mandate to conduct research in both plant and animal science. The Animal Science Section is responsible for research on dairy cattle nutrition, including ruminant mineral biochemistry. The poultry program includes nutrition, physiology, and animal behavior. Although the section serves the livestock industry of British Columbia, it is also recognized nationally and internationally as a centre of excellence.

The Crop Science Section has a broad mandate to undertake research on vegetable management and physiology, postharvest physiology, management of small fruits, weed control, turf, and forage management. These programs are supported by soils research on a wide variety of fertility and soil management problems.

The station has also acquired the mandate for the kiwi fruit program initiated by the Saanichton Research and Plant Quarantine Station several years ago. Kiwi plants are maintained at Agassiz, the Abbotsford Horticulture Substation, and the Kiwi Research Orchard, Sidney, B.C.

The new research feed mill was officially opened in August 1986. This mill provides opportunities to conduct research in livestock nutrition and has the capability to produce newer, more economic feedstuffs. This is the only research facility of its kind in British Columbia.

Further information regarding the research program and results achieved may be obtained by requesting copies of the listed publications and other informal reports. Requests should be directed to the Research Station, Research Branch, Agriculture Canada, P.O. Box 1000, Agassiz, B.C. V0M 1A0; Tel. (604) 796-2221.

J.M. Molnar
Director

ANIMAL SCIENCE

Effect of selenium supplementation on copper metabolism. Eight lactating Holstein cows were fed a diet supplemented with selenium (2.37 mg/kg dry matter) or without selenium supplementation (0.31 mg/kg dry matter) for 276 days of lactation. After 14 days adaptation to the diets, a stable isotope copper-65 was administered intravenously and samples of milk, blood, and liver were obtained at intervals throughout the lactation. The effect of selenium supplementation on the ability of cows to metabolize copper was evaluated by determining concentrations of copper in plasma, milk, and liver, by determining the activities of ferroxidase in plasma and superoxide dismutase in erythrocytes, and by determining the pattern of dilution of the copper-65 in body tissues. Selenium supplementation did not influence any of the parameters of copper metabolism that were tested. It was concluded that an interaction between copper and selenium did not occur under the conditions of this experiment.

Gas chromatographic determination of traces of formaldehyde in milk. A sensitive quantitative method was described for the determination of formaldehyde in milk by packed-column gas chromatography and electron capture detection. Aldehyde derivatization was carried out in situ with 2,4-dinitrophenyl hydrazine. Average recoveries were 96.3 ± 1.6% with an estimated detection limit of 0.026% mg/kg. The technique was used to determine the formaldehyde content of milk from cows consuming a formalin-treated feedstuff.

Growth response of steers to single and sequential hormone implants. Ninety-six Hereford steers were used in an experiment designed to compare the growth response to single or sequential implants of Synovex-S. The experiment was divided into 4-month preliminary, 5-month pasture, and 4-month fattening periods. Comparison of growth rates for the complete trial indicated that the nonimplanted group gained 0.59 kg/day, the groups implanted once gained 0.66 kg/day, the groups implanted twice gained 0.68 kg/day, and the group implanted in all three periods gained 0.68 kg/day. It was concluded that the growth response to sequential implants of Synovex-S was not additive but there was a carry-over in growth response from an implanted to a nonimplanted period.

Influence of light intensity on leg disorders and sudden death syndrome of chickens. Two experiments were designed to test the effect of light intensity ranging from 0.5 to 100 lx on activity, the incidence of leg disorders, and mortality due to sudden death syndrome (SDS). It was concluded that bright lighting ($\geq$10 lx) did not increase chicken activity, rate of SDS mortality, or reduce the incidence of leg disorders by comparison with lower light levels.

Hepatic and cardiac fatty acid composition of broilers dying of SDS. Gas chromatographic analyses of tissue lipids from broiler chickens dying of SDS were carried out to determine if anomalies in fatty acid composition could be linked to the disease. There was a tendency toward desaturation of cardiac and hepatic tissue lipids of male SDS birds. This trend was significant for the triacylglycerol fraction in hepatic lipids. In general, the results of this experiment indicated that a lack of available precursors for prostaglandin synthesis was not a causative factor in the disease.

CROP SCIENCE

Effects of nitrogen application on direct-seeded broccoli. A relatively simple field method was derived and tested to allow single harvesting of broccoli for fertilizer trials, which would allow evaluation of both direct (yield response) and indirect (maturity response) treatment effects. A difference in the response of sweet corn and broccoli to nitrogen applications under similar conditions was shown to be due to the way the rates of the plant uptake and soil transformation processes interact. Since broccoli takes up about the same amount of nitrogen as sweet corn but in a shorter time period, the rates of microbial processes to convert soil nitrogen to a plant available form are not adequate for broccoli. As a result, broccoli can be more dependent on applied nitrogen than sweet corn.

Response of garlic to within-row spacing and to spring versus fall planting. In a 3-year study, planting of garlic in mid-March has consistently resulted in greater yields and larger bulb size than planting in October. Bulb size increases linearly as distance between plants increases. In spring-planted garlic, bulb weight averaged 41 g at a 6 cm spacing and 53 g at 15 cm. Marketable yield decreased from 7.9 t/ha at 6 cm to 5.1 t/ha at 15 cm. Comparable figures for fall planting were 3 t/ha at 6 cm and 0.9 t/ha at 15 cm.

Chemical weed control in newly planted raspberries. The herbicides napropamide, simazine, and terbacil were evaluated when applied singly and in mixture for weed control in newly planted raspberries. Since raspberry plantations are established with either dormant canes or root cuttings, the study compared herbicide effects upon both planting methods. Napropamide (4.48–8.97 kg/ha) gave less than satisfactory to good broad-leaved weed control and excellent annual bluegrass and barnyard grass control. There was little improvement in efficacy with increased rate except when lady's-thumb and shepherd's-purse were the major weeds. Simazine (1.12–2.24 kg/ha) gave good to excellent broad-leaved weed and grass control. Creeping yellow cress invaded the simazine-treated plots later in the season. Terbacil (0.67–2.24 kg/ha) generally gave good to excellent broad-leaved weed and grass control except when common groundsel and pineappleweed were the major weeds. Napropamide caused some initial injury to primocanes, but yields were not affected. Simazine did not injure the crop. Depending on the year and rate, terbacil caused various degrees of injury, which was reflected in decreased yields in plots from root cuttings but not from dormant canes. The most promising treatment was napropamide (1.1–2.2 kg/ha) in combination with simazine (0.6–1.1 kg/ha) or terbacil (0.34–0.67 kg/ha) which caused no crop injury and broadened the weed control spectrum during early establishment of the raspberry plantation.

Energy use in produce storages. Three storage rooms, each with a volume of about 40 m^3 were maintained at 0.5–1°C and >95% relative humidity using three different storage systems. One room was equipped with a Humifresh filacell air handler, the second room was equipped with a jacketed system, and the third was equipped with conventional refrigeration using hot-gas bypass, an oversized evaporator, and a supplementary centrifugal humidifier. Energy consumption was continuously monitored over 22 months using separate kilowatt-hour metres for each room.

The storage room equipped with the Humifresh unit was the heaviest energy user, averaging about 2 kW over the study period. The conventional storage with hot-gas bypass and humidifier was the second-highest energy user, averaging just over 1 kW during the two storage seasons. The most energy efficient system was the jacketed storage which consumed slightly less than 1 kW during the study. Combining information on energy consumption with earlier results on vegetable quality maintenance will permit prudent selection of appropriate storage systems.

Cultivar evaluation of winter cereals. Winter wheat trials have yielded consistently good results and a number of high-yielding cultivars have been identified. In 1986 the cultivars Frederick, Clement, and Monopol topped the list of 12 cultivars tested. According to results from previous years the cultivars Absolvent, Maris Huntsman, and Yamhill can be added to this list. This information is particularly useful at this time when there is increased interest in winter wheat as a cash crop under intensive cereal management for the south coastal region of B.C.

Root-zone amendments for bentgrass turf in sand. The use of sand as a medium for sports turf and golf greens is particularly useful in high rainfall areas such as the south coastal region of B.C. However, establishment in pure sand is sometimes a problem. In a series of microplots constructed in 1985 several amendments were tested to determine their effect on establishment and development of bentgrass turf. The amendments were peat moss, perlite, and clinoptimolitic zeolite, a form of natural aluminosilicate which has been studied for its high cation exchange capacity. Observations during 1986, which took into account both top and root growth, provided convincing evidence that sand amended with peat moss (20% by volume) resulted in more rapid establishment and superior development of the turf. Zeolite-amended plots were next and perlite plots were no better than sand alone.

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D.A. Quinton, B.S., Ph.D.	Range management
D.G. Stout, B.S.A., M.Sc., Ph.D.	Plant physiology
A.L. van Ryswyk, B.S.A., M.S.A., Ph.D.	Soil science

Prince George Experimental Farm

K. Broersma,[2] B.S.A., M.Sc.	Acting Superintendent; Forage agronomy, soils

Departures

A. McLean, B.S.A., M.Sc., Ph.D., F.A.I.C., F.S.R.M. Retired 28 March 1986	Range ecology
W.L. Pringle, B.S.A., M.S.F.; 2-year secondment to the Barani Agricultural Research and Development Project Islamabad, Pakistan	Superintendent; forage

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[1] BI-RES training program, 15 October 1985.
[2] Appointed Acting Superintendent, 14 July 1986.

INTRODUCTION

The research programs at the Kamloops Range Research Station and the Prince George Experimental Farm are designed to serve the ranchers and managers of the diverse range and farmlands of the southern and central interior of British Columbia. Research is focused on developing and transferring new technology in the fields of range management, plant ecology, poisonous plants, bloat, winterhardiness, forage agronomy, quality of conserved forages, and animal nutrition.

The year was marked by the retirement of Dr. Alastair McLean following a distinguished 40-year career in range ecology, most of which was served at this station. Mr. Bill Pringle, Superintendent at the Prince George Experimental Farm, accepted a 2-year secondment to the Barani Agricultural Research and Development Project in Pakistan prior to his retirement from Agriculture Canada. The considerable contributions to agriculture of both of these scientists are acknowledged.

Further information on our research activities is available from the Research Station, Research Branch, Agriculture Canada, 3015 Ord Road, Kamloops, B.C. V2B 8A9; Tel. (604) 376-5565; or the Experimental Farm, R.R. 8, RMD #6, Prince George, B.C. V2N 4M6; Tel. (604) 963-9632.

J.A. Robertson
Director

RESEARCH ACTIVITIES

Nutrition and performance of beef cattle on seeded clearcuts

The diets of beef cattle grazing a seeded area, clearcut of lodgepole pine (*Pinus contorta* Dougl.) and Engelmann spruce (*Picea engelmannii* Parry) at an elevation of 1300 m were evaluated for nutritive value. Liveweight gain of beef cows and calves under continuous and rotational grazing management was obtained concurrently. Dietary protein content of cattle diets under continuous grazing was marginally adequate for cows nursing calves (9.1–9.4%) over the season (July through September), whereas the protein content of the diet of cattle on the rotationally grazed pastures was adequate only for maintenance of dry stock during August (7.1%) and September (6.9%). The phosphorus content of cattle diets was below recommended levels during August (0.22%) and September (0.17%) for cattle grazing the rotationally grazed pastures. Copper concentrations were marginal (4.5 ppm) during July and inadequate during August (3.4 ppm) and September (3.0 ppm) in cattle diets on both grazing treatments. Iodine was deficient (0.38–0.16 ppm) in the forage diets of both herds. Zinc was marginally adequate (31.8–24.5 ppm) except for the August diet (16.2 ppm) of the rotationally grazed pasture herd. Total beef production was 21.6 kg/ha and 19.8 kg/ha from the continuously grazed and the rotationally grazed pastures, respectively.

Pasture bloat in cattle

Ruminal chlorophyll levels and rates of passage of two water-soluble markers were simultaneously determined in cattle with different susceptibilities to alfalfa pasture bloat. The markers showed a slower rate of passage from the rumens of more susceptible cattle, where the average half-life periods for Co-EDTA and Cr-EDTA were 12–17 h. In the rumens of the less susceptible animals, the average half-life of the markers was 8 h. In agreement, chloroplast particles in the liquid phase of rumen contents showed a greater accumulation in bloat-susceptible animals. Differences in rumen volumes (estimated from the quantity of marker administered and its initial concentration) were detected among animals but these did not show a relationship to bloat susceptibility. In vitro studies indicated that alfalfa chloroplast particles were not readily degraded by rumen microorganisms.

Timber milkvetch (*Astragalus miser* var. *serotinus*) poisoning

In a 4-year study, rumen fluid was obtained from cattle on various diets and supplements to determine the effects of different inocula on the microbial degradation of 3-nitropropanol (NPOH), the toxic metabolite of timber milkvetch (TMV). In vitro assays were also conducted on nitrite (NO_2^-) metabolism since rapid NO_2^- reduction is required for the overall detoxification of NPOH. Sulfite supplements were ineffective and produced toxic signs in treated animals. Fresh pasture diets enhanced the in vitro metabolism of NO_2^- but rates of NPOH metabolism were not significantly affected. Rates for NPOH were enhanced when orchardgrass pasturage was supplemented with molasses. The induction of NPOH metabolism was achieved with supplements of nitroethane given intraruminally at 6.5 or 10 mg/d. The effect of nitroethane on NO_2^- reduction was not always observed but the NO_2^- rates of metabolism always exceeded those of NPOH. The rates of NPOH degradation also increased when nitroethane was added to a molasses supplement. The sodium salt of nitroethane, given intraruminally at 20 mg/kg body weight, produced the highest rates of NPOH degradation and these were similar to those reported for 3-nitropropionic acid, a nitroalkane which is much less toxic to ruminants than NPOH. This additive appears to be innocuous at the levels tested, since treated cattle showed no signs of debilitation and methemoglobin concentrations were not elevated.

Measurement of freezing injury to cyanogenic plants

Certain plant species, such as bird's-foot trefoil (*Lotus corniculatus* L.), contain cyanogenic glycosides and enzymes that can break down these glycosides; however, these glycosides and enzymes are normally physically separated from each other by cellular membranes. When the membranes are damaged, the enzymes can come into contact with the glycoside releasing hydrogen cyanide (HCN) gas. A method to evaluate viability following freezing that is applicable to leaves of cyanogenic plants was developed.

The method involves the change of color of a paper disc impregnated with alkaline picrate from yellow to orange-brown, owing to reaction with HCN release from injured leaves. All leaves and leaflets of bird's-foot trefoil released HCN following freezing injury and had similar LD_{50} values. Leaves that will produce about the same amount of HCN can be obtained near the middle of a plant. Results obtained with this qualitative HCN test were similar to results obtained with existing tests of viability. The main advantages of this test are that it does not expose the plant material to an unnatural situation, and that it allows for more killing temperature measurements for a given labor investment.

Fall harvesting of alfalfa

There is a belief that cutting alfalfa (*Medicago sativa* L.) during a 4–6 week critical period before the first fall frost interferes with development of cold hardiness and thereby results in winter injury. An experiment was conducted to determine the effect of taking the third and final cut at various times (biweekly 15 August to 1 November) during this hypothetical fall critical period. Harvesting the third cut on 15 August caused the most decrease in the yield of the first cut in the next year (>10%); thus the critical fall harvest period is from about 15 August to 15 September. This period does not fall within the proposed 4–6 week period before the first fall frost. It is believed that the August critical period may be related to interference with tiller development rather than interference with cold hardiness.

Alfalfa winter injury

Substantial winter injury to alfalfa (*Medicago sativa* L.) occurred in interior British Columbia during the 1985–1986 winter. Seven alfalfa cultivar trials were in test at the Kamloops Research Station during this severe winter providing an opportunity to obtain valuable information regarding the relative winter hardiness of different alfalfa cultivars and genotypes.

Beaver, a standard cultivar in each trial, showed high winter survival (77–100%). Rambler and Spredor II had survival ratings similar to those of Beaver. Anchor and Vernal each had about the same survival rating, but were less winterhardy than Beaver, 55–84% and 52–92%, respectively. Survival of Algonquin was similar to Vernal and Anchor.

Four verticillium wilt resistant cultivars (Apollo II, Trumpetor, Vertus, and WL316) were much less hardy than Beaver (15–46%). Within this verticillium wilt resistant group, the survival ranking was generally Apollo II > Trumpetor = Vertus > WL316; however, the differences were often not statistically significant. Apollo II showed better survival ($P \leq 0.05$) than WL316 in two trials. In two trials Apollo II was similar to Vernal and Anchor, but in another trial, Apollo II was less hardy than Anchor.

Two verticillium wilt resistant cultivars showed quite good winter survival. In the 1985 seeded trial, Oneida VR (73% survival) showed much better survival than Vertus (46%) or WL316 (34%). Barrier showed better survival than WL316 and/or Vertus in three trials. Oneida VR and Barrier survived as well or nearly as well as Vernal and Anchor.

Remote sensing – grasslands manual

The manual describes techniques for using Landsat and airborne (23 × 23 cm and 35 mm format) imagery to identify and map vegetation complexes of several forb, grass, shrub, and tree species of the native grassland ranges of British Columbia. The study considered time and scale of photography, and film type (normal color and infrared color). Frequent on the ground observations at various growth stages of the vegetation at or near the time that the imagery was obtained were made to positively identify the vegetation complex units detected on the imagery.

The manual provides direction for the use of the cheaper 35 mm photography to obtain sample transects in concert with new Landsat imagery in a multistage approach to range assessment. Combined with the practical knowledge of range managers, this approach should prove to be a very useful tool for providing much more frequent monitoring of the trends of range condition and current range use.

Analytical method for determining phosphorus in calcareous soils

Acid-fluoride techniques are widely used for determining phosphorus (P) content of soils and plant material. However, on calcareous soils, neutralization of the acid by soil carbonates has resulted in underestimates of available P. In this study the effects of five soil phosphorus extractants (Bray P1, 1:10, soil volume to extractant volume; Bray P1, 1:50; Mehlich II; Kelowna I; and Kelowna II) on post extraction pH and the correlation between soil and plant P concentrations were determined. Alfalfa was grown in five calcareous and six noncalcareous soils fertilized at 0 and 90 µg/cm of P in a growth room experiment. The ability of the extractants to maintain a low pH with calcareous soils was poorest for the Bray P1 (1:10) followed by the Mehlich II, Kelowna I, Kelowna II, and Bray P1 (1:50). With the calcareous soils, a statistically significant correlation coefficient between soil and plant P concentration was obtained with all methods, except the Bray P1 (1:10). However, the best correlations were obtained with the Kelowna extractants.

Effects of cropping systems on Luvisolic soils

The effects of four cropping systems on crop yield, and the chemical and physical properties of a Luvisolic soil were determined. Cropping systems included continuous barley (grain), continuous bromegrass (hay), continuous red clover (hay), and a rotation of barley (grain) and a grass–legume mixture (hay). Yields of barley following forage were significantly higher than for continuous barley. Continuous grass was the only treatment which increased soil organic matter. Soil aggregates under continuous grass were more water stable than those under other cropping systems. Water infiltration rates were also highest for the continuous grass treatment.

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Saanichton Research and Plant Quarantine Station Sidney, British Columbia

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INTRODUCTION

Saanichton Research and Plant Quarantine Station is the ornamentals and greenhouse vegetable research centre for British Columbia and is responsible for the national postentry quarantine program. Research is conducted in floriculture, greenhouse and field vegetables, nursery plant production, virus eradication, tissue culture, and biological control of pests and diseases. Greenhouse technology research includes energy conservation, utilizing solar energy, thermal blankets, and a computerized climate control system. Requests for information or publications should be addressed to the Saanichton Research and Plant Quarantine Station, 8801 East Saanich Road, Sidney, B.C. V8L 1H3; Tel. (604) 356-6650.

C. J. French
Acting Director

ORNAMENTALS

Management

Post-harvest storage of pot chrysanthemums. Ten commercial varieties of pot chrysanthemums were evaluated for storage performance. Plants were grown to maturity, wrapped with plastic sleeves, and packaged into cardboard boxes or onto open shipping trays. Pots were stored at 4°C for 2 weeks in the dark and then brought at room temperature (18°C) for 2 weeks to evaluate quality. The major problem observed was yellowing, dead, and diseased lower foliage. Based on quality grading, three varieties were good, four saleable and the other three poor. Results indicate that cold storage of pot chrysanthemums for up to 2 weeks is possible. Final quality depends on selection of varieties, and packaging method and storage conditions, or both.

Micropropagation of Alstroemeria. Conventional multiplication of *Alstroemeria* by rhizome division is slow due to the large stock plant requirement. This study investigated tissue culture for propagating *Alstroemeria*. Among various tissues tested, rhizome tips were found to be suitable. Satisfactory initiation and shoot development were achieved but rooting improvements are required before this technique can be used in virus elimination and induced mutation of *Alstroemeria*.

Diseases

Virus diseases of ornamentals. Viruses were detected in 56% of 105 *Alstroemeria* samples collected from three B.C. commercial growers. Of 39 cultivars sampled 46% and 5% were universally infected with alstroemeria mosaic virus (AMV) and alstroemeria carlavirus, respectively. A few cultivars were also infected with unidentified spherical viruses. Leaf mottling and mosaic were the only apparent symptoms in infected plants, and AMV was the only virus associated with these symptoms.

Two unidentified cultivars of florists' hydrangea were mechanically inoculated with a hydrangea isolate of alfalfa mosaic virus (AMV). In one cultivar, all developed characteristic foliar mottling. AMV was reisolated from this cultivar and subsequently identified by electron microscopy and immunodiffusion tests. No virus was recovered from the other cultivar, which remained symptomless. The results demonstrate pathogenicity of AMV in florists' hydrangea and suggest that some cultivars may be virus resistant.

SMALL FRUIT

Management

Kiwi fruit production on Vancouver Island. Bud burst occurred in late March 1986; however, full bloom was not reached until late June, 2–3 weeks later than in other seasons. Fruit growth was measured from fruit set until harvest. Changes in fruit growth rate are similar in all varieties, with a rapid growth phase during the first 90 days. Fruit maturity was monitored from mid September to mid November 1986 using both young and old plants of a number of varieties. Fruit on younger plants matured more rapidly than on old plants but the pattern of change was similar.

Average fruit size in Hayward was over 100 g and the fruit shape and yield per plant were satisfactory. Fruit of two local selections, Saanich 10 and 12, although of an acceptable average fruit weight, had a ribbed external appearance, were often flattened, and had stiff hair, making handling and packaging more difficult. Fruit storage characteristics and the efficiency of pollination in the different varieties will also be investigated.

Kiwi fruit cold tolerance and frost protection. Changes in cold tolerance of containerized kiwi fruit plants and tissue pieces were studied. Whole plants were chilled at three stages of development in the spring of 1986 and twice in the fall. Tissue pieces excised from field grown plants were treated at the same intervals. Cold tolerance decreased with increased bud development in the spring in both whole plants and tissue pieces.

Organogenesis and plantlet regeneration following in vitro cold storage of kiwi fruit shoot tip cultures. Shoots were cut from kiwi fruit shoot tip cultures previously stored at 8°C for 52 weeks, from cultures 52 weeks old maintained at the shoot proliferation stage at 23°C, and from proliferating cultures 8 weeks old. Excised shoots were recultured in proliferation medium for one month and in vitro organogenesis was examined. There were no differences between the three types of shoot cultures in terms of fresh weight gain and shoot production. However, the number of roots produced was greater from the cold-stored cultures than from cultures maintained at the proliferation stage. All plantlets regenerated from all three treatments survived. Thus, storage of kiwi fruit shoot tip cultures in vitro for 52 weeks at 8°C does not impair subsequent in vitro organogenesis of subcultured shoots nor plantlet regeneration.

Elimination of two grapevine nepoviruses in vitro by an alternating temperature regime. A 40-day in vitro treatment with 6 at 39°C followed by 18 at 22°C was effective in eliminating both grapevine fanleaf virus (GFLV) and arabis mosaic virus (AMV) from grapevine shoot tip cultures. Longer treatment durations with alternating 12 periods at 35°C and 22°C eliminated GFLV in some cases but did not eliminate AMV.

VEGETABLES

Management

Edible soybeans for south coastal British Columbia. Seven short-season, white hilum soybean varieties were seeded in the spring (4 June 1985 and 22 May 1986). All varieties except for OT 83-4 in the 1985 growing season and Evans in the 1986 growing season were ready for harvest in October. The highest yielding variety in 1985 was KG20 with 3166 kg/ha followed by Maple Arrow 2845 kg/ha, Maple Isle 2753 kg/ha, McCall 2643 kg/ha, Evans 1904 kg/ha, and Maple Ridge 1648 kg/ha. Lodging was minimal. Growing early maturing soybean varieties on Vancouver Island looks promising. However, drying the beans before storage will be needed.

Pepino (Solanum muricatum), a new greenhouse crop. Pepino is a new greenhouse crop from South America. Fruit shape is ovoid and, at maturity, is yellow with purple stripes. The fruit is juicy with an aroma and taste of melon. Pepino cuttings from the cultivars El Camino, Schmidt, Dulce, and seedlings from selected plants were grown in glass and plastic greenhouses. Plants were grown in peatlite and sawdust mixes and were trained to a single stem in a similar fashion to greenhouse tomatoes. A lower nitrogen level (96 ppm) induced more flowering than a higher level (151 ppm). Poor fruit set was obtained on all cultivars. Plants grown in sawdust had higher fruit set than in the peatlite mix.

Comparative yields of greenhouse tomatoes in sawdust and nutrient film techniques (NFT) culture. Three tomato cultivars (Creon, Vedettos, and Bruinsma 2084) were seeded on 25 November 1985 and transplanted to sawdust and NFT systems on 31 January 1986. Harvesting commenced on 9 April and terminated after 10 weeks. No significant differences were found between the two growing systems nor were there interactions between cultivars and growing systems. Creon produced more fruit but a reduced percentage of No. 1 fruit, a reduced percentage of large fruit, a reduced mean fruit weight, and a higher percentage of culls. There were no significant differences between the yield parameters of Vedettos and Bruinsma 2084. These results show no advantage in changing from a sawdust to an NFT growing system to obtain higher yields.

Greenhouse sweet pepper production. Five greenhouse sweet pepper cultivars (Lito, Novi, Gold Crest, Yellona, and Violetta) were seeded 17 June 1985 and planted in sawdust culture on 31 July.

Harvesting commenced 27 September 1985 and continued until 30 June 1986. Fruits were harvested at the mature stage (Yellona and Gold Crest, yellow; Novi, red; Violetta, black; and Lito, white). There was a marked decrease in yield from the end of November to early March for all cultivars. This was attributed to decreasing radiation levels and day length. Lito produced more fruit than the other cultivars but at the expense of a lower fruit weight. Both Lito and Novi produced more fruit by weight than the other cultivars. Yellona, Novi, and Gold Crest all produced higher percentages of No. 1 fruit than Violetta and Lito. Violetta and Lito produced more culls than the other three cultivars.

Diseases

Control of Fusarium crown and root rot through lettuce feed. Coplanting of lettuce with tomatoes reduces the incidence of *Fusarium* crown and root rot. The present trial was conducted to determine if similar protection could be achieved by feeding tomatoes nutrients from NFT cultured lettuce.

Two NFT and one sawdust growing system were investigated. In one NFT system nutrients were continuously recirculated to the tomato plants from a parallel lettuce crop. In the other systems, nutrients from a separate NFT lettuce system were regularly added to the tomato feeding tank.

At first flowering all plants were inoculated with *Fusarium*. Eight weeks later the plants were harvested and disease development assessed. Results detected no significant effect of lettuce nutrients on *Fusarium* infection of tomato in any system.

Amblyseius cucumeris for biological control of thrips on greenhouse cucumbers. The western flower thrips, *Frankliniella occidentalis* Pergande, is the major pest of greenhouse cucumbers in British Columbia and resistant to most registered greenhouse insecticides. Due to the routine use of biological controls for greenhouse whitefly and two-spotted spider mite by growers, the development of a pesticide-based control program is undesirable. A predatory mite, *Amblyseius cucumeris* Oudemans, was reared to sufficient quantities for trials. Greenhouse cucumbers were infested with thrips and *A. cucumeris* and released twice, the first time at 100 per plant and the second at 200 per plant. Over a 6-week period, *A. cucumeris* maintained thrips populations at or below 30 nymphs per leaf whereas control plants increased to 200 larvae per leaf. Mite populations increased to and stabilized at 15 per leaf on the treated plants. In a second 14-week trial *A. cucumeris* held populations of western flower thrips at or below 10 per leaf and mite populations increased in response to increasing thrips populations. *Amblyseius cucumeris* is a potential biological control for thrips pests on greenhouse cucumbers.

PLANT QUARANTINE

Virus indexing of tree fruit and grape. In 1986, 116 tree fruit and 15 grape varieties were received from noncertified sources for virus indexing. There are currently 182 grape varieties and 75 tree fruit varieties in the heat therapy program, and this year, 1 *Pyrus*, 14 *Malus*, 32 *Prunus*, and 23 *Vitis* clones were released. The repository consists of 643 tree fruit varieties and 224 grapevine varieties. Tests are continuing on the reduction of indexing period and the evaluation of new virus elimination and detection techniques. Research is also being conducted on the effects of new viruses on grapevine growth parameters.

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Research

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INTRODUCTION

The Summerland Research Station, located in the Okanagan Valley of southern interior British Columbia, conducts research concerned primarily with solving problems of production and utilization of tree fruits and grapes with the objectives of increasing production efficiency, reducing production costs, and providing high quality products to consumers. Studies are also carried out at substations located at Kelowna to the north and Creston to the east and in growers' orchards and vineyards in the Okanagan, Similkameen, and Creston valleys. Cooperative involvements in research with food processing companies extend Canada-wide.

A major event in 1986 was completion and occupation in December of a new 12 036 m^2 office–laboratory building with a 716 m^2 attached greenhouse. Staff previously occupying a number of outdated buildings were moved into the new building, which houses extensive new equipment including transmission and scanning electron microscopes and a more versatile food processing pilot plant area. A phytotron with 90 controlled environment rooms will permit more extensive studies involving growth of plant material, insects and diseases, coldhardiness of plant material, and controlled atmosphere storage of harvested fruit.

This report contains brief statements of some major achievements attained at this establishment in 1986. Further information may be obtained from publications listed at the end of this report or from individual scientists. Requests for information or reprints should be addressed to the Research Station, Research Branch, Agriculture Canada, Summerland, B.C. V0H 1Z0; Tel. (604) 494-7711.

D.M. Bowden
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ENTOMOLOGY–PLANT PATHOLOGY

Integrated pest management (IPM) for virginiacreeper leafhopper on grapevines

An integrated pest management program to control the virginiacreeper leafhopper in a commercial vineyard continued to be effective for the sixth consecutive year. This management program has reduced the cost of control by 67–75% since 1981. It is based on the preservation of an endemic leafhopper egg parasite, *Anagrus epos* Girault, by applying sprays of carbaryl 50 WP with active ingredient (a.i.) at 275 g/ha only when leafhopper populations exceed a threshold of five nymphs per leaf and restricting the timing of spray applications to after 80% hatch of eggs of each breed of leafhoppers. In 1986, populations of first and second summer brood leafhoppers were suppressed by this parasite to noneconomic levels in the perimeter and central core areas of 2 ha blocks of Foch and Okanagan Riesling grapevines. Parasitism of the second brood leafhopper eggs ranged from 23.0 to 58.4% on biweekly leaf samples collected from the Foch block and from 25.5 to 65.3% on those from the Riesling block. No treatments with carbaryl were required. Since 1981, a total of three complete sprays plus one spot treatment were applied whereas in most vineyards one to two sprays are required annually.

Effect of Insegar and diflubenzuron on fruit tree leafroller egg eclosion

The fruit tree leafroller is univoltine. Eggs are oviposited onto the tree bark in the summer and the insect overwinters in this stage. Diflubenzuron, an insect chitinase inhibitor, and Insegar (Maag Agrochemicals), an insect growth regulator, applied to Spartan trees before and during egg deposition, both reduced larval emergence when the egg masses were allowed to develop in the laboratory. When the egg masses were allowed to develop in the orchard, fewer larvae emerged from those exposed to Insegar versus diflubenzuron and the control. When both chemicals were also applied against early instar larvae, only the diflubenzuron treatment reduced larval feeding damage compared to the control treatment; however, the damage level, 15%, n = 747, was too high to be tolerated in a commercial orchard. Application of the insect growth regulator onto the trees during egg deposition in order to control fruit tree leafroller within the orchard the following year would offer a new strategy for control of this insect.

Pesticide effects on apple tree photosynthesis

Torque (Ciba-Geigy Canada Ltd.), an acaricide, significantly elevated photosynthetic rates in Golden Delicious apple trees in the orchard to 139.71, 156.67, and 118.60 of untreated control tree values 24, 120, and 168 h post-treatment, respectively.

In a greenhouse experiment with Red Delicious apple trees the acaricides propargite and Apollo (Nor-Am Chemical Co.) increased the photosynthetic rate to 130.45 and 123.68% of the control value 24 h post-treatment. Cyhexatin reduced the rate to 77.81% of the control value 24 h post-treatment but increased the rate to 165.52% of the control value at 96 h post-treatment. Savey (DuPont Canada Inc.) reduced the rate to 73.95 and 81.13% of the control value at 96 and 192 h post-treatment, respectively. A sulfur-containing fungicide, Safer's Fungicide (Safer Agrochem Ltd.), reduced the rate to 77.83% of the control rate at 192 h post-treatment. This information should prove useful both in modeling efforts and for pest management purposes when choosing the optimum pesticide for adjusting the numbers of a pest population.

Phytophagous mite feeding influences on apple tree photosynthesis, crop quality, and yield

Phytophagous mite numbers, primarily European red mite and apple rust mite, were adjusted to three densities on two strains of Red Delicious apple trees, and mite populations were assessed in terms of mite-days, a measure that accounts for both the number of mites feeding and the duration of their feeding. When photosynthetic rates of spur leaves were measured biweekly for the duration of the growing season and regressed against biweekly accumulations of mite-days there was a significant negative relationship. As mite-days increased the photosynthetic rate decreased and there was no significant difference between strains. Large mite-day values were associated with significantly reduced weight of crop, fruit acidity, soluble solids, and color intensity whereas they were also associated with significant increases in fruit firmness and percentage of fruit surface colored. The highest values for mite-days were associated with peak population sizes approximately twice as large as currently recommended economic thresholds.

Insect growth regulators for control of codling moth

Insecticides currently recommended to control codling moth on apples and pears are toxic to many beneficial organisms in orchards. Several insect growth regulators kill codling moth eggs but not beneficial organisms.

Insegar (Maag Agrochemicals) with a.i. at 50 g/100 L, HOE 000522 (Hoechst Canada Inc.) with a.i. at 15 g/100 L, and diflubenzuron with a.i. at 10 g/100 L were applied to apple trees with a gun sprayer during periods of oviposition as timed by a degree-day codling moth development program. Based on damage at harvest from codling moth, all three materials provided as good control as azinphos-methyl, a standard insecticide. One application of an insect growth regulator during each brood of codling moth was adequate provided the first brood application was made at the beginning of egg hatch rather than the beginning of oviposition. This is probably because residues from the earlier timed application are diluted by the rapid foliage growth during early spring.

A possible biological control of crown rot and apple replant disease

Crown rot of apple trees, caused by *Phytophthora cactorum* (Leb. & Cohn) Schroeter and apple replant disease caused by biotic and abiotic factors are serious soil-borne diseases in the Okanagan Valley of British Columbia. Strain B8 of *Enterobacter aerogenes* (Kruse) Hornaeche & Edwards, isolated from a local soil, produces diffusible antibiotics antagonistic to the growth of *P. cactorum* and to biotic causal agents of apple replant disease. Under greenhouse conditions, *E. aerogenes* reduced crown rot infection of McIntosh apple seedlings and increased seedling growth in apple replant problem soil that had been pasteurized and fertilized with ammonium phosphate. In an orchard, *E. aerogenes* applied as a soil drench significantly reduced the rate of infection of apple trees on MM106 rootstocks artificially inoculated with *P. cactorum*. In another field test, trees naturally infected with *P. cactorum* and treated with *E. aerogenes* as a soil drench remained alive and produced normal crops of fruit while untreated trees became terminally diseased and succumbed over the following 3 years. In an orchard with apple replant problem soil, drenches of *E. aerogenes* significantly increased the growth of M26 apple rootstocks compared to untreated controls. Best growth responses were obtained with combined treatments of formalin, ammonium phosphate, and *E. aerogenes*. In addition to an increase in tree growth, *E. aerogenes* may protect trees from crown rot infection. These results indicate the potential of *E. aerogenes* as a biological control agent for field control of two serious diseases: crown rot and apple replant disease.

Incidence of *Mucor* spp. in Okanagan d'Anjou pear orchard soils

Mucor piriformis Fischer causes a stem end decay of stored d'Anjou pears. A survey was conducted to determine the incidence of this fungus in Okanagan pear orchard soils. *Mucor* spp. were found in 49 of 51 orchards sampled in the Naramata–Penticton area and in 32 of 32 orchards sampled in the Kelowna area of the Okanagan Valley. Thirty-six isolates of the 49 samples from the Naramata–Penticton area were pathogenic on d'Anjou pear fruit and have been identified as *Mucor piriformis*. Because some of the orchards had much higher populations of the fungus than others, it was recommended that the fruit from these orchards should be run through the fruit packing lines last to reduce the possibility of increasing the contamination of the cleaner fruit.

Apple scab resistance to benomyl and dodine

A few orchards in the Vernon–Kelowna area of British Columbia reported ineffective control of apple scab, *Ventura inaequalis* (Cooke) Winter, in the spring of 1986. A survey of 28 orchards was conducted to determine if apple scab was resistant to benomyl and dodine. Eight of the orchards were found to have greater than 50% of the apple scab conidia in samples resistant to 1 ppm benomyl. Resistance to 1 ppm benomyl as determined by the bioassay used will result in loss of field control when the fungicide is applied at currently recommended rates. Low levels of resistance to dodine were detected in a few orchards. Recommendations have been made to growers for the management of this resistance problem.

An internal rot of stored Spartan apples

Apples removed from controlled-atmosphere storage at a large packinghouse in June 1986 were found to have an internal rot of unknown cause. Approximately 10% of the late stored Spartan apples were affected. There was no visible sign of the infection on the outer surface of the fruit. The rot emanated from the core and was found in the soft parenchyma tissue, usually encircling the core and discoloring from 5 to 75% of the apple interior. Examination of 93 apples with this type of rot confirmed that every fruit contained fungal hyphae. Isolations made from 32 of these apples onto potato dextrose agar indicated that the fungus was a basidiomycete because 24 of the 32 isolates examined had distinctive clamp connections. This fungus appears to be closely related to the low temperature basidiomycete (LTB) which causes a bull's eye rot symptom on the surface of stored apples and pears.

FOOD PROCESSING

Pilot scale production and composition of juice from heated pear mashes

High-temperature short-time thermized Bartlett and d'Anjou pear mashes were enzyme treated, decanter centrifuged, settled, and filtered to produce 350-L batches of high quality pear juice (A_{420} = 0.08–0.10). Centrifuged juice recoveries averaged 76.3%. Analysis for glucose, fructose, sorbitol, sucrose, °Brix, malic, citric, and galacturonic acids, titratable acidity, Na, K, Mg, Ca, amino nitrogen, and viscosity showed some differences between varieties. Bartlett fruits contained more citric acid and amino nitrogen and less malic acid and sodium than d'Anjou. Phenol determination by high-performance liquid chromatography showed Bartlett juice to contain (+)-catechin, (−)-epicatechin, caffeic acid, and chlorogenic acid while d'Anjou juice phenols were almost all chlorogenic acid. Ultraviolet scan gave A_{280}/A_{420} of 1.38 and 1.01 for Bartlett–d'Anjou juices. Galacturonic acid ranged from 0.74 (d'Anjou) to 0.67 g/100 mL (Bartlett). Sensory evaluation indicated that the juices were acceptable and varietal differences were low so a common blend could be produced from the two varieties.

The Canada Agriculture Blanch Effluent Recycling System

The Canada Agriculture Blanch Effluent Recycling System (CABER) has been tested for its ability to concentrate dissolved solids and generate steam. The commercial prototype unit is a vertical tube-in-shell heat exchanger where the heating medium is oil heated by a natural gas fired boiler. Blanch effluent is circulated through the heat exchanger where low-pressure steam is generated and returned to the blancher while dissolved solids are concentrated to a predetermined level and bled off. This system would thus reduce the load on waste disposal facilities and the concentrated effluent is a potential animal feed supplement. At an inlet oil temperature of 134°C, maximum steam production was 120 kg/h when pure water was used as the substrate, but decreased to 97 kg/h when a high-solids sugar solution was used. Under simulated average-use conditions, the unit developed 108 kg/h of steam while using 11.043 m^3 of natural gas for a thermal efficiency of 62%. The maximum concentration of dissolved solids attained from blanch effluent was found to depend on the source and composition of the effluent.

Control of brown pigments in apple juices

Apple juice color constitutes an important sensory attribute of this widely consumed product. Development of the color of a finished juice is a complex chemical process dependent on a variety of processing conditions. The experiments reported employed controlled conditions of polyphenoloxidase mediated oxidation, both on and off the mash, to determine whether final juice color could be effectively manipulated through this processing step. Four dessert apples, McIntosh, Golden Delicious, Red Delicious, and Spartan were studied. Cultivar-based differences were noted for color (A_{420}) and phenol content of juices subjected to induced oxidization for up to 90 min. It was found that oxidation on the mash produced a lighter colored juice than oxidation in the juice. Results indicated that careful control of phenol oxidation on the mash will allow a juice to be processed to a finished color within specified ranges.

POMOLOGY AND VITICULTURE

Effect of orchard soil management on soil temperature and apple tree nutrition

Soil temperature was measured from 1981 to 1985 at 0.2 and 1.0 m depths for four soil management treatments which included full ground cover, total vegetation control, shallow tillage, and black plastic mulch in a high-density orchard planted to Bisbee Red Delicious (apple) on M.26 rootstock. Ground cover suppression treatments, especially black plastic mulch, increased degree-day accumulations above 10°C in all 5 years at a depth of 0.2 m and in 3 years at a depth of 1.0 m relative to full ground cover. These treatments also resulted in more extreme temperature fluctuations as characterized by higher summer maximum and lower winter minimum temperatures under black plastic mulch. Despite the more extreme soil temperatures, apple yield was significantly higher under black plastic relative to full ground cover. For these two contrasting temperature treatments, leaf N and Mg concentrations were usually significantly higher under black plastic while leaf P and K were consistently higher and leaf Ca and Zn were occasionally higher under full ground cover. Most of these differences were, with the possible exception of leaf Zn, attributed to the competition for, or recycling of, nutrients by orchard floor vegetation. Mean monthly soil temperatures at the two depths under the four soil management treatments could be predicted by simple linear regression techniques from soil temperature measurements at the Summerland Research Station meteorological recording site.

Hedging De Chaunac grapevines

French–American hybrid grapes are prone to excessive vigor. Foliage removal by hedging is often warranted to reduce this vigor. The major purpose of this trial was to assess the impact of three levels of summer hedging at 5, 10, and 15 nodes in combination with three timings, postbloom (P), full canopy development (F), and veraison (V), on all pertinent vineyard attributes.

Hedging severity reduced vine size linearly, but this was partially a consequence of shoot biomass removed during the previous summer. A slight increase in berry weight was observed in 10F and 15F vines in late July at full canopy. Berry weight was optimized in the 5P treatment.

Most hedging treatments influence fruit composition. Anthocyanins and °Brix varied inversely with severity and directly with earliness of hedging. Highest °Brix was observed in 15F vines, while anthocyanins were maximized by the 15P treatment. Both parameters were minimized by the 5F treatment. Total acidity (TA) did not differ between treatments despite the delay in fruit maturity, due to enhanced cluster exposure resulting from severe hedging. The 15V vines had lowest TA, whereas highest TA was found in 10P vines.

Canopies were characterized by point quadrat analysis, photometry, and measurement of leaf area. Cluster exposure varied directly with severity and inversely with earliness of hedging (15 nodes severity only). Point quadrat analysis indicated canopy density varied inversely and cluster exposure directly with hedging severity. Percentage of contacts which were clusters or gaps were highest at five nodes severity. Total leaf area varied inversely with severity of hedging, and effects of timing on leaf area were reflective of lateral shoot growth. Both point quadrat analysis and measurement of leaf area components helped explain vine response in terms of fruit composition and berry weight. Although hedging reduced °Brix and color, effects were relatively small. Early and/or light hedging may be a reasonable vineyard practice to reduce TA and bunch rot through improvements in canopy microclimate.

Freezing patterns in dormant peach flower buds

The flower primordium of overwintering flower buds of peach avoids freezing by supercooling. The supercooling of the flower primordia is dependent on water migration from the base of the flowers' primordium to preferential sites of freezing in the flower bud scales and pith during the initial stages of freezing. The preferential freezing which occurs in the flower bud scales and pith does not appear to be caused by a difference in distribution of ice nucleators. Nucleation begins in the shoot and spreads into the flower bud. The flower primordium, however, appears to have an intrinsic resistance to ice nucleation in comparison to other parts of the flower buds which may be related to its lower water and osmotic potential. The lower osmotic potential of the flower primordium appears to be a consequence of higher sucrose levels than that of the vascular tissue below the flower buds and that of the flower bud scales which indicates that osmotic adjustment may be occurring in these cells.

Effects of thinning and summer pruning on fruit quality of Stella sweet cherry

Flavor, firmness, size, and freedom from handling and storage-related surface marking of sweet cherries are usually better in seasons or on trees with a light crop load. Furthermore, fruits high in calcium are believed to be inherently firmer and have a longer storage and shelf life than low calcium fruits; and calcium levels in most fruits can be increased by removing competing vegetative growth during the period of fruit development on the tree.

In a 2-year experiment, the crop load on Stella cherry trees was systematically reduced by removing either flowers or young fruit. Coupled with these treatments, all actively growing shoots on one half of each tree in the experiment were cut back during a 3-week period prior to harvest.

Reducing the crop by as little as 25% led to a significant increase in fruit size and fruit firmness, but the amount of improvement was too small to be of practical importance. Also, removal of vegetative shoots during May and June led to significantly higher levels of calcium in the fruit but this effect was not associated with any notable improvement in fruit firmness or storage quality. Thus, it was concluded that flower or fruit thinning and summer pruning, while physiologically effective, are of little horticultural value to the B.C. sweet cherry industry.

Shamrock apple

The naming of the Shamrock apple culminates a number of years of breeding and selection work aimed at developing a green apple to compete with the Granny Smith apple, which requires a longer season to mature than is available in Canadian apple-growing areas. Shamrock matures at Summerland about 10 September, a few days before McIntosh. Its color and shape are nearly identical to Granny Smith. The taste is juicy and tart with a good sugar-acid balance. Its aroma is mild at picking maturity but in fully mature apples is reminiscent of McIntosh which, along with Golden Delicious, is a parent of Shamrock. The Shamrock tree's compact and spurry growth habit results in good precosity and productivity. Its thick canopy of leaves should help prevent sunburn and red color development. Trees of Shamrock are being propagated by local nurseries and scionwood is available.

SOIL SCIENCE AND AGRICULTURAL ENGINEERING

Drainages and water use

Drainage measurements from soil under apple trees, with and without grass cover crop, have been made over a period of 9 years in lysimeters. The trees were irrigated regularly at a variety of levels ranging from 37 to 100% of normal for the Summerland area. The 9-year average drainages, from the time the trees were planted to when they were fully mature, were 29 and 40% of the irrigation amounts on the grassed and ungrassed lysimeters. The drainages ranged from lows of 1 and 18% to highs of 45 and 57% of the irrigation amounts on grassed and ungrassed lysimeters. The low figures accompany a year when irrigation was 37% of normal whereas the high figures accompany a year of 100% of normal irrigation.

As percentages of irrigation plus annual precipitation the 9-year averages of drainages dropped to 19 and 27% of the total water receipts annually. The year-to-year variability of drainage was very large, ranging from almost no drainage in some years to more than half the irrigation water in other years. The amount and timing of annual precipitation, the general weather conditions and hence the patterns of evapotranspiration, all affect the patterns of drainage but the single most significant factor in inducing drainage was the level of irrigation.

Water use by apple trees in irrigated lysimeters

Water use as calculated by differences between water added and drainages ranged from about 8 to 16 L per tree per day with grass cover and from about 7 to 14 L per tree per day with bare soil, depending to some degree, but far from entirely, upon the level of irrigation. These quantities of water per tree are particularly noteworthy when compared with the quantities of water applied to orchards, in the Okanagan and elsewhere. For example, an orchard of 500 trees per hectare would receive about 194 L of irrigation water per tree per day. The lysimeter studies have indicated that a mature tree can be grown and produce fruit crops with far less water per tree per day than an orchard receives. The difference is related to the tree densities of orchards and the area occupied by each tree compared with the total area irrigated. In the orchard of 500 trees, each tree can be assigned an area of 20 m^2 whereas in the lysimeters each tree had only 2.3 m^2 of area. These water-use to water-applied relationships have particular relevance to trickle irrigation with which very much smaller areas are irrigated per tree than under the blanket irrigation from sprinklers.

Distribution of soil Zn fractions in British Columbia interior orchard soils

The distribution of soil Zn fractions was determined for 20 representative orchard soils from the British Columbia interior. Medium to high levels of total Zn were measured (52–226 mg/kg) with an average of 90 mg/kg. A sequential fractionation showed that 0.3–23% of total Zn was exchangeable, 0.5–30% was associated with organic matter, 1.3–15% was associated with Fe and Al oxides and 46–92% was residual. A separate determination indicated that 6–24% soil Zn was associated with Mn oxides. Except for the Fe and Al oxide fraction, amounts of Zn in the fractions were significantly positively correlated with total Zn, and also with Bray-1 P and organic matter content. Zinc in the exchangeable and organic fractions was negatively correlated with both pH and residual Zn. This suggested a redistribution of soil Zn from the residual fraction into the exchangeable and organic fractions upon acidification.

The observed range of total Zn and exchangeable Zn suggests that a wide range of Zn availability could exist in B.C. interior orchard soils. The work is being extended to find the relationship between soil Zn and Zn deficiency under greenhouse conditions and in 40 commercial apple orchards.

Effect of various lime, gypsum, and nitrogen fertilizer treatments on movement of lime in soil columns

Soil columns were used to study downward movement of calcitic and dolomitic lime applied at two rates on the soil surface or incorporated 0–5 cm deep in combinations with gypsum and surface-applied N fertilizer. The columns were irrigated with 800 mm of deionized water applied over 3 weeks. The calcitic and dolomitic liming materials were equally effective in raising soil pH at the lower depths. Neither gypsum nor fertilizer nor doubling the liming rate had much effect on lime movement. Incorporation of the liming materials, however, greatly accelerated their downward movement in soil.

Shallow incorporation of lime could be carried out without fear of serious tree root damage under most orcharding conditions and this method, together with other treatments, is now under investigation in a field experiment.

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A. Luczynski, M.Sc.	Plant resistance to mites
B. Lyons, M.Sc.	Spiders in polycultures
D.J. McKenzie, Ph.D.	Monoclonal antibodies to plant virus proteins
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INTRODUCTION

This 24th annual report of the Vancouver Research Station outlines some of the activities within our dual mandate, as national center for plant virus research and plant health biotechnology; and the responsibility to assist producers in the lower mainland of B.C. and other parts of the province, in control of pests and diseases.

We were pleased to celebrate the 25th anniversary of the founding of this station late in 1985, and the 100th anniversary of the Research Branch in 1986. Despite our venerable age, we are replacing the retired scientists with young ones, so that research productivity and transfer of knowledge to our various clients continues at the usual high level.

Further details of research or reprints of this report, and the publications listed can be obtained from the scientists or from the Research Station, Agriculture Canada, 6660 N.W. Marine Drive, Vancouver, B.C. V6T 1X2; Tel. (604) 224-4355.

M. Weintraub
Director

VIRUS CHEMISTRY AND PHYSIOLOGY

Biotechnology

The N-terminal cyanogen bromide peptide of the coat protein of the cowpea strain of southern bean mosaic virus (SBMV-C) was used as an immunogen in the production of monoclonal antibodies. One monoclonal antibody, designated 4D6, bound to both purified peptide and immobilized virus in a solid-phase ELISA. The reactivity of this monoclonal antibody with immobilized peptide could not be inhibited by native SBMV-C but was inhibited by low levels of EDTA-swollen virus in an antigen inhibition ELISA. Reactivity of the antibody was also observed with native virus particles, which had been dialysed against weakly alkaline buffers. The binding of 4D6 was extremely sensitive to trypsin proteolysis of the virus coat protein, indicating that the antibody binding site was probably located within the first 30 amino acid residues of the N-terminus.

Nucleotide sequence relationships among 17 tobamovirus isolates determined by dot blot hybridization using ^{32}P-labeled cDNA probes, placed them into nine distinct taxonomic groups, of which two were new. Extensive sequence similarity between strains of a group indicated the possible usefulness of antisense RNA in limiting infection by related strains. However, sequence differences between groups might prevent intergroup protection by this mechanism.

Complementary DNAs (c-DNAs) were synthesized to the high molecular weight ds-RNA of apparently virus-free *Phaseolus vulgaris* cv. Black Turtle Soup. The c-DNAs were cloned in plasmid and phagemid vectors of *E. coli* and a clone, designated pBT2, representing 630 bases of the bean ds-RNA, was characterized by molecular hybridization and its DNA was sequenced. The ds-RNA and pBT2 hybridized to DNA from various plant species. Sequence analysis revealed a potential open reading frame but no m-RNA homologous to pBT2 was detected in RNA extracted from Black Turtle Soup bean. A computer search of the EMBO 8.0 data bank showed that the cloned region has homology with a region of the *E. coli* genome and with the genomes of two animal retroviruses. The significance of these sequence relationships is not known. The probable origin of the ds-RNA in Black Turtle Soup bean appears to be the chloroplast but its function in the plant is unknown.

Physical, chemical, and serological properties of virus in vitro

The dissociation of immunoprecipitates of three monoclonal antibodies (B5, B6, and B10) with southern bean mosaic virus was assessed at pH values between 7.0–2.25 by density gradient analysis and by indirect ELISA. Both methods showed that B10 did not dissociate appreciably, B5 dissociated at pH 2.75–2.25, and B6 dissociated at pH 3.5–2.25. Purified virus was recovered from a B6 affinity column by pH gradient elution at pH 3.4–2.2 or by elution of virus swollen with 2 m*M* EDTA in pH 7 buffered saline. Virus partially purified by polyethylene glycol or by chromatography on Sephacryl S-300 was recovered by pH gradient elution, but clarified sap of infected plants destroyed the reactivity of the B6 affinity column. Electron microscopy showed virus particles on B6 agarose beads at higher pH values and the release of virus into lower pH washes.

The proteins of the sobemovirus turnip rosette virus (TRosV) and *Prunus* strain of tomato bushy stunt virus (TBSV-P) were cleaved with cyanogen bromide, and highly basic peptides were isolated by ion-exchange chromatography. The amino acid composition and sodium dodecyl sulfate–polyacrylamide gel electrophoresis indicated that the basic peptide from TRosV had 40 amino acid residues, including 11 basic residues. This peptide had a composition similar to basic peptides isolated from the sobemoviruses, sowbane mosaic virus, and two strains of southern bean mosaic virus. The amino acid composition and size of the basic peptide from TBSV-P were similar to those found for the amino terminal sequence of the type strain of TBSV.

Virus infection

The aphicide pirimor, 2-dimethylamino-5,6-dimethylpyrimidin-4yl-dimethylcarbamate, is a pyrimidin derivative. Because of its close chemical similarity to structural components of viral and other RNAs it was tested for its possible effect on virus infection. Leaves were either: sprayed with a solution of pirimor and inoculated with virus several days later; allowed to take up the solution via their petioles for several days, then inoculated; or inoculated with a mixture of virus and pirimor. None of these applications reduced the number of lesions caused by TMV on leaves of *Nicotiana glutinosa*.

Ultrastructural responses to virus infection

Leaf cells of *Hesperis matronalis* infected with turnip mosaic virus (TuMV) contained an unusual array of virus-like particles in addition to the tubular and laminated cytoplasmic inclusions typical of TuMV infections. Virus-like particles were often seen as a uniseriate array of particles, perhaps attached to a membrane; the resulting mono-layer of particles was loosely rolled to form a jellyroll like structure, which was confined to the cytoplasm.

Virus transmission by seed and pollen

About 20% of seed of cowpea (*Vigna unguiculata*) obtained from Hungary was shown to be infected with a cucumovirus. Diagnosis was based on virus morphology and ds-RNA analysis of infected tissue. The virus did not react with antibodies to cucumber mosaic virus (CMV), the type member of the cucumovirus group, and end-labeled (^{32}P) ds-RNA did not hybridize to the CMV ds-RNA. The unknown virus may be cowpea ringspot virus or a previously undescribed virus of cowpea.

Little cherry disease (LCD)

Preparations obtained from leaves of young, certified virus-free Mazzard F12/1 cherry trees produced by tissue culture, were found to contain flexuous virus-like particles (VLP) similar to those in LCD-infected sweet cherry field trees. They reacted strongly in serology-specific electron microscopy (SSEM) with two polyclonal antisera prepared against VLP from LCD-sweet cherry from the Okanagan and VLP from a group of old sweet cherry trees outside the Okanagan–Kootenay areas. However, the VLP from healthy Mazzard did not seem to originate from vascular tissue, nor were they accompanied in situ by the vesicular and cylindrical cellular inclusions typical of LCD field trees.

PLANT PATHOLOGY

Nematology

Grapes. To assess the potential impact of the presence and the distribution of nematode vectors of nepoviruses in grapes, vineyards of the Okanagan and Similkameen valleys were surveyed. Of 290 samples from 83 vineyards, *Xiphinema occiduum* was recovered from 95% of the vineyards surveyed. This species transmits tomato ringspot virus between cucumber seedlings in the laboratory and is presumed to be a vector of nepoviruses in grape. In the vineyards its mean density was 61/L of soil and the highest count was 1300/L. Multiple regression analysis showed that age, vine species, soil texture, and pH affect the number of *X. occiduum* recovered. A new species of *Xiphinema*, closely related to *X. californicum*, was discovered in two vineyards near Oliver.

Raspberry. The population dynamics of the root lesion nematode, *Pratylenchus penetrans*, were followed in plots of raspberry after applications of a post plant nematicide and/or organic manures. Vydate drenches were applied in the root zone with a.i. at 1 kg/ha on 15 April, 15 August, and 15 October 1985, and on 14 April, 18 August, and 16 September 1986. Chicken manure was applied at 11.5 or 5.7 t/ha, with or without Vydate. The light application of manure did not depress the nematode populations. All the other treatments, especially the heavy rate of manure, lowered nematode density in the roots or in the soil.

Bacteriology

Serological and biochemical characteristics of *Erwinia carotovora* subsp. *atroseptica* strains from potato were determined and compared to other pectolytic *Erwinia* strains. Analysis of the biochemical characteristics showed that the *E.c. atroseptica* strains formed a distinct phenotypic cluster. Sixty-three percent of these strains typed into serogroup I. Other strains in this cluster typed into serogroups XVIII, XX, or XXII. A number of the latter strains also expressed additional O antigens not utilized in typing but known to be present in *Erwinia* strains of other phenotypic clusters.

Monoclonal antibodies were produced to the lipopolysaccharide O antigen used in serotyping of *E.c. atroseptica* serogroup I. Immunoblot analysis of lipopolysaccharide separated on polyacrylamide gels indicated that the monoclonal antibodies reacted with the 0-side chain and not the core region. The antibodies reacted specifically with serogroup I and XXII strains but not with other serogroups of *E.c. atroseptica*, *E.c. carotovora*, or *E. chrysanthemi*. In enzyme-linked, immunosorbent assays, the monoclonal antibodies reacted with extracts from blackleg-infected stem tissue but not with extracts from healthy potato stem tissue.

A procedure to purify pectate lyase from *E. carotovora* was developed to evaluate this bacterial product as antigen for serodiagnosis. The purification procedure was based on the affinity of the enzyme for its substrates, sodium polypectate, and polygalacutonic acid. Enzyme was eluted from substrate, precipitated with calcium chloride, with 1 *M* sodium chloride.

Development of bacterial ring rot caused by *Corynebacterium sepedonicum* was evaluated in six potato cultivars. Foliage and tuber symptoms differed among the cultivars in time of appearance and severity. Populations of bacteria in infected stems ranged from 8.3×10^6 to 1.1×10^{10}/mL of sap but population levels were not correlated with cultivar nor with presence of disease symptoms. Less than 20% of progeny tubers from infected plants of all cultivars had ring rot symptoms but the number of tubers set by infected plants was up to 68% less than the number set by uninfected plants. Reduced tuber set appeared to occur independently of symptom severity.

Fungal pathology

Cranberry. Blighted twigs, collected from cranberry fields in May of 1985 and 1986, and fruit samples collected in late September of 1984 and 1985, were examined for fungal organisms. Lophodermium upright dieback, caused by *Lophodermium oxicocci*, was the most common twig blight in both years, followed by those caused by *Fusicoccum putrefaciens* and *Diaporthe vaccinii*. Fruit rots found were yellow rot caused by *Botrytis cinerea*, black rot by *Ceuthospora lunata*, viscid rot by *Diaporthe vaccinii*, end rot by *Fusicoccum putrefaciens*, hard rot or cotton ball by *Monilinia oxicocci*, a fruit rot by *Phyllostica elongata*, early rot by *P. vaccinii* and a fruit rot by *Sporonema oxicocci*. Black rot and end rots were the most common fruit rots in all cultivars. Cotton ball was severe in one unsprayed field of the cultivar, Bergman, in 1985.

Blueberry. Helicopter spraying was evaluated for the control of mummy berry of highbush blueberry, caused by the fungus *Monilinia vaccinii-corymbosa*. Excellent control was obtained using the standard fungicide application rate for fixed-wing aircraft (110 L water + 2.8 L triforine formulation per hectare). Although the amount of triforine could be reduced to 1.4 L/ha, it was not possible to reduce the amount of water applied and still get good control.

Raspberry. To evaluate the feasibility of using tissue cultures for testing for root rot resistance, tubed tissue cultures of the raspberry cultivars Skeena, Meeker, and Newburgh were inoculated with Ribeiro isolate of *Phytophthora erythroseptica*, the causal agent of raspberry root rot. Good root rot symptoms were apparent within 14 days of inoculation but resistance ratings did not correlate with those determined in bench tests. The physical changes in plant structure exposed to constant high humidity increases the susceptibility of the plants, reducing the value of the test.

Virology

Blueberry scorch disease is a relatively new disease in the Pacific Northwest, which was first observed in 1980. The disease has many similarities to sheep pen hill disease of blueberry reported from New Jersey. A causal agent has not been determined for either disease. During the summer of 1986 we looked at the possibility of a virus being the causal agent of blueberry scorch disease. Transmission electron microscopy of thin-sectioned blueberry material showed virus-like particles in infected bushes but not in healthy bushes. In virus purifications from 14 infected bushes and 14 healthy bushes, we found virus-like particles in all 14 infected bushes but in only one of the healthy bushes. This bush was from a field that has many infected bushes and may have been infected recently. Graft transmission from field-infected plants induced symptoms on healthy Collins plants, but attempts to transmit the virus mechanically to herbaceous hosts, either from blueberry or from purified preparations, have been unsuccessful. The virus-like particles are about 700 nm long and 14 nm in diameter with a coat protein of 33 000 daltons and a RNA about 3.5×10^6 daltons.

In 1986 a survey for raspberry viruses in western Washington and British Columbia included material from plant propagators, commercial fields, breeding plots and native *Rubus* sp. All samples were tested in three ways: mechanical transmissions to *Chenopodium quinoa*; enzyme-linked immunosorbent assay (ELISA) for tomato ringspot (TomRSV) and raspberry bushy dwarf (RBDV) viruses; and double-stranded RNA analysis (dsRNA) which should detect any RNA virus. Of 440 samples tested 65 were infected with raspberry leaf spot virus, 22 with RBDV, 8 with TomRSV, and 7 with tobacco streak virus. There was good agreement between the ELISA and dsRNA tests for TomRSV and RBDV. The mechanical transmissions agreed very well with the other tests early in the season but, predictably, were less reliable during the second half of the summer.

Small fruit breeding

Raspberry. Two new cultivars, Chilliwack (tested as 74-10-81) and Comox (tested as 74-12-42), were named in 1986. Chilliwack produces large, firm, glossy, medium red fruit of exceptionally high quality. The fruit has some resistance to both pre- and postharvest fruit rots and is suited either to fresh or processing usage. Plants have some resistance to root rots. Comox also produces large, firm fruit and has been noted for its very high yield not only in the Pacific Northwest but in trial plantings in Ontario, Scotland, and Norway. The fruit is well-suited to processing but can also be used for fresh market. Both cultivars are resistant to the aphid vector of the raspberry mosaic virus complex.

Strawberry. A new cultivar, Sumas (tested as 69-5-34), was named in 1986. This cultivar produces high yields of large, relatively firm fruit suited to processing or to early fresh market. Plants are winter hardy, virus tolerant and have some red stele resistance. Advanced selection 76-7-20 was placed into growers trials. It produces large, firm, glossy, medium red fruit suited to fresh market. If it performs satisfactorily in 1987, it will be named.

ENTOMOLOGY

Vectors

Aphid survey. New records brought the number of known aphid species in British Columbia to 386. Aphids have now been collected from 865 different host plants and the total number of aphid–host plant associations is 1660.

Pest control

Potato aphid monitoring. To minimize infection by aphid-borne viruses, seed potatoes are usually top-killed before peak flights of the main aphid vector *Myzus persicae*. The later the killing date, the greater the yield. To determine the optimum date, the size and timing of aphid flights were monitored for the past 4 years in strategic commercial potato fields in the Fraser Valley. In 3 years, top-killing was safely delayed 3–5 weeks. In 1986, however, due to delayed planting and slow growth of the potatoes, tops could not be killed when monitoring indicated an early major flight was imminent. Even so, no symptoms of potato leaf roll or other viruses were evident in fields or in the Florida tests. Apparently the major virus threat of the 1960s has abated and increased seed potato production in the Fraser Valley may be possible.

Virus survey. 1986 was the first year of a 4-year survey for potato leaf roll virus (PLRV) and beet western yellows virus (BWYV) in potatoes in the lower Fraser Valley of British

Columbia. Approximately 5500 potato plants were collected from commercial fields, backyard gardens, and cull piles for diagnosis by ELISA. Results indicate that the major source of PLRV inoculum is in backyard gardens, and that efforts should be made to eliminate this source. BWYV was seldom found in the potatoes sampled.

Ermine moth (*Yponomeuta malinellus*). This introduced pest is now widely distributed in the Fraser Valley where apple root grafting stocks are grown. Washington State has imposed a quarantine and requires mandatory methyl bromide fumigation of apple stocks from British Columbia. In a series of tests, no insecticide dip was fully effective against diapausing larvae on apple seedlings. To assess the level of parasitization, larvae were reared from over 200 egg masses and colonies but no parasites were found. This suggests the need to import potential biological control agents from Europe.

Cranberry insects. In tests to control the blackheaded fireworm, *Rhopobota naevana* (Hbn.), two sprays of Lorsban 4E-HF (chlorpyrifos) with a.i. at 0.54 kg/ha were applied to cranberry foliage 30 May and 21 July. Control was excellent. The best control for the larvae of the cranberry girdler, *Chrysoteuchia topiaria* (Zeller) was Lorsban 4E-HF with a.i. at 2.24 kg/ha, in water equivalent to 3000 L/ha, and washed in with 6 mm of water either by rain or by sprinkler. Lorsban 15G applied at the same rate and frequency gave the next best control of girdler larvae and was better than Diazinon 5G, Diazinon 50EC, Dipel 10G, Lance 10G, and Furadan 10G.

Pheromones proved effective in monitoring peak flights of both cranberry girdler and blackheaded fireworm moths and were helpful in timing spray applications against these insects. Saturation of a 4-h block of cranberries with pheromone of the female blackheaded fireworm indicated that some disruption of the mating of the moths occurred.

Twospotted spider mite. A simple, quick, and unbiased sampling method for *Tetranychus urticae* was derived from small experimental field plots in 1985. In 1986 larger field tests in ten commercial strawberry fields in the Fraser Valley indicated that the sampling method was both valid and effective. By this method mite densities can be determined up to 10 times faster than by conventional methods. It is now economically feasible to obtain the data on pest status that are required to make informed pest management decisions. A pilot project will be initiated to introduce the method to growers and pest managers.

Field experiments suggested that the native predator, *Amblyseius fallacis* is capable of regulating *T. urticae* below the economic threshold. *A. fallacis* collections from the Fraser Valley were resistant to commercially recommended concentrations of malathion, diazinon, cyhexatin, and endosulfan, but were susceptible to dimethoate, dicofol, demeton, and carbofuran. Since demeton and carbofuran are recommended for aphid and weevil control respectively, there is a potential for *T. urticae* outbreaks when these pesticides are used.

Lettuce aphid. Demeton (Systox), a key systemic insecticide used to control lettuce aphids in B.C. was withdrawn from use in 1986. Towards developing an effective replacement for this chemical, seven insecticides were evaluated to identify suitable candidates for the minor use of pesticides registration program. The results verified that systemic insecticides were more efficacious than nonsystemics. Disulfoton (Di-syston) was even more effective than demeton, with acceptable residues at harvest. Application is now progressing for minor use registration of disulfoton against lettuce aphids.

Tuber flea beetle. Several granular insecticides were evaluated for efficacy and longevity against first generation tuber flea beetles in potatoes. These insecticides were tested at different rates, at various profiles in the soil, and at three locations with differing soil types. Two systemics, Thimet (phorate) and Counter (terbufos) gave control as good as, or better than, the currently used Temic (aldicarb). It was also demonstrated on a commercial scale that granular insecticides for control of tuber flea beetle in table grade potatoes can be reduced by 75%. Granular Thimet was placed only on the outer rows of a commercial potato field, where tuber flea beetles are known to be most prevalent. This procedure, combined with weekly insect monitoring, provided excellent insect control, with only one additional spray being required.

Residue chemistry

Lettuce aphid. To support minor use registration, disulfoton was evaluated once more for control of the lettuce aphid. Disulfoton was again found to be effective and residue levels in the marketable produce were negligible (<0.1 ppm). Depending on the preharvest interval, the concentrations ranged from nondetectable (detection limit 0.002 ppm fresh weight) to 0.05 ppm. Results of efficacy and residue studies were submitted for minor use registration.

Cabbage maggots. Residue studies of chlorpyrifos in Brussels sprouts were completed. No residue was detected in the plants 85 days after band treatment with chlorpyrifos granules. Based on results of our efficacy and residue studies, application for minor use registration of Lorsban 15G was approved for cabbage maggot control in cole crops (Brussels sprouts and rutabaga).

Degradation of vinclozolin. Vinclozolin, the active ingredient of a relatively new fungicide Ronilan 50 WP, was found to be susceptible to hydrolysis. Two degradation products, a carbamic acid and an amide were identified. When Ronilan 50 WP was applied to pea leaves approximately 70% of the residues were removable by water within 7 days. The removable residues increased to about 80% after 14 days and 90% after 30 days.

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